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THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THE PROBLEM OF SEVERAL BODIES: RECENT PROGRESS IN ITS SOLUTION[1]

I

THE DIFFERENTIAL EQUATIONS AND THEIR TRANSFORMATIONS

WHITTAKER has formulated the classic problem of three bodies as follows: Three bodies attract each other according to the Newtonian law so that between each pair of particles there is an attractive force which is proportional to the product of the masses of the particles and the inverse square of their distances apart: they are free to move in space and are initially supposed to be moving in any given manner; to determine their subsequent motion.

In mathematical phraseology the problem is to integrate a certain system of the eighteenth order of differential equations which at present are usually written in the so-called canonical form

$$dx_i = \frac{\partial F}{\partial p_i}\,dt, \quad dp_i = -\frac{\partial F}{\partial x_i}\,dt,$$

in which t is the time, x_i a coordinate, p_i a component of momentum, and F a certain function of all the x_i and p_i.

In recent investigations, especially those originating in the researches of Poincaré, the canonical equations are preferred to other types because of their simplicity of

[1] Abstract of the address of the vice-president and chairman of Section A—Astronomy and Mathematics—American Association for the Advancement of Science, Baltimore, 1908.

form, ease of transformation and perspicuity in showing how the variables enter the problem. It becomes of advantage, then, to expand the function F in terms of canonical elements; Charlier has given in his lectures a method of expansion which Norén and Wallberg carried out to terms of the second degree. Stone has published a simple direct derivation of the canonical elements introduced into the three-body problem by Delaunay and Jacobi; while the formulæ of transformation from Cartesian to Jacobian coordinates in the n-body problem have been derived by Pizzetti with the aid of linear substitutions.

From the standpoint of the theory of integral invariants introduced by Lie and Poincaré the characteristic property of the canonical system is the existence of the relative integral invariant $\int \Sigma x_i dp_i$, and the covariantive correspondence between the canonical system and the differential expression $\Sigma x_i dp_i - F dt$ forms the connection between their theory and that of contact transformations. A systematic study of integral invariants has been published by De Donder, including his own researches and those of Appell, Hadamard and Koenigs. Morera has shown in a series of memoirs how this transformation theory gains in generality, simplicity and elegance when at its foundation we lay the bilinear covariantive correspondence to which allusion has just been made; Morera rediscovers and generalizes the theorems of Lie on the invariance of canonical systems under contact transformations. The importance of these results for the problem in hand is recognized when we recall that Lagrange's method of the variation of arbitrary constants in the theory of perturbations leads to equations of the canonical form; Lie's theory thus stamps the history of a perturbation problem as the history of a contact transformation, a relation exhibited on the geometrical side by the true orbit enveloping the successive approximate ones. The notion of an intermediate orbit has been extended to canonical systems by Charlier, who has employed it in a generalization of Jacobi's theorem.

Lagrange showed that the eighteenth order system in the three-body problem can be reduced to one of the sixth order; this reduction has been effected in a variety of ways by other mathematicians. Poincaré employed a contact transformation to reduce the problem to the twelfth order, and Whittaker has used an extended point transformation to carry the reduction on to the eighth order. Whittaker has also exhibited in explicit form the contact transformations involved in Radau's direct reduction from the eighteenth to the sixth order. Routh's transformation known as the ignoration of coordinates has recently been generalized by Woronetz to a form which includes as special cases Poincaré's equations of motion, and the reductions of Lagrange, Jacobi, Bour and Brioschi. The discovery of the existence of a force center in the three-body problem has enabled Delaunay to write its equations in a special form. Scholz has shown that under certain assumptions regarding the perturbative function the three-body problem can be reduced to the integration of a single differential equation, and a new reduction of the plane problem has been given by Perchot and Ebert. The corresponding reduction of twelve units in the order of the n-body problem has been effected by Bennett through Poincaré's transformation and a generalization of the one employed by Whittaker in the three-body problem.

In the transformation and reduction of the problem a principal rôle has been played by the ten known integrals, namely, the six integrals of motion of the center of gravity, three integrals of angular mo-

mentum, and the integral of energy. The question of further progress in this reduction is vitally related to the non-existence theorems of Bruns, Poincaré and Painlevé. Bruns demonstrated that the n-body problem admits of no algebraical integral other than the ten classic ones, and Poincaré proved the non-existence of any other uniform analytical integral. A strikingly instructive example illustrating these non-existence theorems has been given by Perchot and Ebert. Painlevé has generalized Bruns's theorem by showing that, in addition to the classical integrals of energy and momentum, there exists neither integral nor integral equation algebraic in the velocities, and the theorem of Poincaré, by proving that there exists no new analytical integral uniform with respect to the velocities. Gravé showed that the three-body problem under forces varying as any function of the distance possesses no new integral independent of the law of attraction, and this theorem has been generalized for the n-body problem. Bohlin has very recently added to the non-existence theorems by demonstrating that the mutual distances in the problem of three bodies can not be expressed as the roots of an algebraical equation of the fifth degree with transcendental coefficients.

II

PARTICULAR SOLUTIONS AND THEIR GENERALIZATIONS

In 1772 the prize of the Académie Royale des Sciences de Paris was awarded to Lagrange for an "Essai sur le Problème des Trois Corps." In this celebrated memoir Lagrange "shows that the complete solution of the problem requires only that we know at each instance the sides of the triangle formed by the three bodies; the coordinates of each may then be determined without difficulty. As for the solution of the triangle, it depends upon three differential equations, of which two are of the second order, the third of order three." He determined all the solutions of the problem in which the ratios of the mutual distances of the bodies remain constant. In one of the two distinct configurations the bodies are always at the vertices of an equilateral triangle; in the other they lie always on a straight line. In both of these cases the motion of each body relative to either of the others is the elliptic motion of the two-body problem. Tscherny has constructed these solutions geometrically; he has also shown that the only cases of the three-body problem for which known mathematical and mechanical means suffice are those which reduce to the problem of two bodies. Lagrange's solutions were originally discovered in his problem of the mutual distances; the latter, called by Hesse the reduced problem, has recently assumed a new form under Charlier's treatment, in which the mutual distances are replaced by the distances from the center of gravity. From Lagrange's discussion certain imaginary considerations were omitted; Whittemore has filled this gap, but the completed discussion yields no other real solution. The equilateral triangular solution is possible for all distributions of the masses; their distribution on the straight line is defined by the real positive root of a certain quintic equation; Frederigo has given a new derivation of this equation and Bohlin has formulated four developments, of which three represent the roots of the quintic in three distinct domains, and the fourth for an isolated value. The question of the stability of the solutions furnishes Levi-Civita an example of his theory of stationary motion in which reappear the results of Liouville and Routh, namely, the triangular solution is stable if

$$(m_1 + m_2 + m_3)^2 > 27\,(m_1m_2 + m_2m_3 + m_3m_1),$$

while the rectilinear solution is always unstable.

Theoretical interest in the Lagrangian solutions has been increased by Sundman's theorem that the more nearly all three bodies in the general problem tend to collide simultaneously, the more nearly do they tend to assume one or the other of Lagrange's configurations; and on the other hand practical interest in them has been revived by the discovery of three small planets, 1906 T.G., 1906 V.Y., 1907 X.M., near the equilateral triangular points of the Sun-Jupiter-Asteroid system. Linders has begun the investigation of the motion of the first of these by starting from a periodic solution of the differential equations and developing the Jupiter perturbations from the osculating elements.

Lehmann-Filhés, Hoppe and Dziobek have generalized the exact solutions to cases of more than three bodies placed on a line or at the vertices of a regular polygon or polyhedron, and isosceles triangular solutions have been studied by Fransen, Gorjatschew and Woronetz, while Longley in an investigation of the plane problem of invariable configuration pays special attention to the rhombus. The cases considered by Dziobek and Lehmann-Filhés have been generalized by Pizzetti in a direct study of the homographic motion of n bodies. Among the most interesting extensions of Lagrange's theorem are those due to Banachiewitz and Moulton. The former considers a non-equilateral triangular system with fixed center of gravity and under attractions according to the inverse cube of the distance. He finds a particular solution in which the triangle rotates around the x-axis, its angles remaining constant, and each point describing a curve on a cone of revolution about the same axis which projects into a spiral on the base of the cone. This is the first case of an exact solution in which three finite bodies describe curves of double curvature. Moulton's case is that of the four-body problem consisting of three arbitrary masses, in motion according to either of Lagrange's solutions, and an infinitesimal body; there are eighteen solutions of arbitrary period in which the finite bodies lie on a line, and ten in which they are at the vertices of an equilateral triangle. Periodic solutions analogous to those in the restricted three-body problem have been constructed for Moulton's problem.

The method of Lagrange's memoir has been extended to the four-body problem by Seydler and more recently by Woronetz; the latter has pointed out particular solutions in which three of the bodies are equal; these solutions are given by quadratures if the law of force is inversely as the cube of the distance and are capable of direct extension to the case of any number of bodies.

III

PERIODIC SOLUTIONS AND THEIR APPLICATIONS

The Lagrangian solutions remained the only known periodic solution of the problem of three bodies for one hundred and five years until 1877, when Hill, in his epoch-making researches on the lunar theory, demonstrated the existence of a periodic solution which could serve as the starting point for a study of the moon's orbit. With these memoirs he broke ground for the erection of the new science of dynamical astronomy whose mathematical foundations were laid broad and deep by Poincaré. Up to the time when Hill's work appeared, mathematical astronomers were accustomed to assume a solution of the problem of two bodies as a first approximation in the lunar theory; which intermediate orbit includes none of the inequalities due to the sun's disturbing

force. Hill proposed to take as this first approximation an orbit which would include all the inequalities depending upon the mean motions of the sun and moon. The old theories consisted essentially in suitably varying a solution of the problem of two bodies, while Hill's theory seeks the true orbit by attempting to vary appropriately the restricted problem of three bodies. During the last fifteen years, Brown has published a series of papers, concluding with the 1907 Adams Prize Essay of the University of Cambridge, which extend Hill's work to the construction of the most perfect of all the ten or eleven theories of the moon which have appeared since Newton's "Principia." Hill found periodic solutions of the motion of a particle in a plane under the influence of two bodies which revolve round each other in circular orbits and whose distance apart is infinite. In its initial stages Brown's theory modified Hill's solution in two particulars, first by reducing the distance of the two bodies to finite dimensions, and thus introducing the inequalities which involve the solar parallax, and second by including those inequalities which are due to the moon's eccentricity. Adequate accounts of these theories are given in the presidential addresses delivered on the occasions of the award of the gold medal of the Royal Astronomical Society to Hill in 1887, and to Brown in 1907, while the relations of Brown's perfected work to the highly original pioneer work of Hill are exhibited in the introduction which Poincaré has written to Hill's "Collected Works." Brown has recently finished his complete numerical theory, and lunar tables based upon it are to be published by Yale University. His numerical results furnish an interesting confirmation of the validity of Newton's law. Newcomb proposed an explanation of the motion of Mercury's perihelion by changing the exponent 2 in the Newtonian law to $2 + 0.00000016$. Brown finds in his theory of the moon's motion that the exponent can differ from 2 only by ± 0.00000004.

The work reviewed up to this point in our discussion has found its sources in Hill's periodic solution, the memoir of Lagrange, the non-existence theorems of Bruns and Poincaré, and Lie's theory of contact transformations; that which follows may trace its origins to Poincaré's theoretical and Darwin's numerical investigations on periodic solutions, Newcomb's and Lindstedt's solutions in trigonometric series, Gyldén's theory of absolute orbits, and Painlevé's theorems on the singularities of the problem.

Although periodic and asymptotic solutions do not exist in nature their services to astronomy have been two-fold: to the practical astronomer in supplying first approximations to orbits under investigation, and to the mathematical astronomer in opening the way to further theoretical researches through what Poincaré has characterized as "la seule brèche par où nous puissons essayer de pénétrer dans une place jusqu'ici reputée inabordable." Darwin has constructed a splendid collection of examples of these orbits, planetary and lunar; among his most curious satellite orbits are perhaps those which present three new moons in a month, and another which has five full moons in one period. Darwin's orbits were subjected to a searching analytical examination by Poincaré who showed that two sets of curves which Darwin treated as continuous can not be considered as such; the true sequence of the orbits in question has been exhibited by Hough. Certain of Darwin's results have been derived analytically by Charlier, and specially with reference to the families of oscillating satellites in the vicinity of the five centers of libration corresponding to the exact Lagrangian solutions. In Char-

lier's paper no account was taken of the imaginary centers of libration; the analytical treatment was completed in this particular by a note which showed that there are imaginary centers about which real orbits exist. Plummer has extended Charlier's analysis to arbitrary fields of force, and to terms of the second and third orders in the developments. Schlitt has reckoned five orbits to whose construction Darwin referred as not belonging to the category of simply periodic orbits, and for that reason disregarded by him. With Darwin's orbits Moulton has compared certain of his own, established by Poincaré's method of analytical continuation, and arranged in power series rather than Fourier series. Finally to Darwin's orbits Strömgren has applied his conditions for cusps and loops in the restricted three-body problem; Strömgren has shown that these singularities may be encountered in every point in the plane, in the absolute motion as well as in that referred to moving axes.

Periodic orbits have been variously classified. If the curves are reentrant after a single period Darwin calls the orbits "simply periodic"; all the orbits considered by him have this property. Hill has grouped them broadly into two classes: the first contains those in which a rotation of the whole system has taken place; the second, those in which no such rotation has occurred, but the longitudes of the bodies and their distances have returned to the same values. Poincaré has classified them elaborately into species, classes and kinds, but as Charlier has pointed out this classification is not exhaustive. The great majority of the orbits referred to here belong to the first two kinds, as distinguished by Poincaré, that is, they either have inclination and eccentricity zero or inclination zero and eccentricity not zero. Von Zeipel has published a thorough study of the solutions of the third kind—that is, those having both inclination and eccentricity different from zero—in which they are grouped in no fewer than ten types and their stability discussed by the aid of their characteristic exponents. Whittaker has designed a criterion for the discovery of periodic orbits analogous to those theorems which indicate the positions of the roots of an algebraic equation.

A matter of vital theoretical and practical import in the domain of periodic solutions is the question of their stability. Following Poincaré's lead, Brown has formulated the sufficient conditions for stability in the n-body problem as follows: first, that the bodies never become infinitely distant from one another; second, that their mutual distances never descend below a certain limit; third, that each body passes an infinite number of times as near as we wish to any point through which it has once passed; fourth, that a small external disturbance shall not affect the fulfillment of these conditions. Poincaré stated the first three and investigated the third in detail; numerical limits for the first and second have been found by Haffel in a particular case of the sun-earth-moon system. Levi-Civita has worked out criteria in which the stability is made to depend upon that of a certain point transformation associated with the periodic solution; these criteria show the instability of certain orbits which in the first approximation appear to be stable; they indicate further that contrary to accepted opinion a purely imaginary characteristic exponent α does not always single out a stable solution—the solution is unstable if $\alpha/\sqrt{-1}$ is not commensurable with the mean motion $2\pi/T$. Applying his method to the restricted problem Levi-Civita has found that solutions differing little from circles and having a mean motion $1 + 3/h$ are certainly unstable, thus

proving the existence of zones of instability surrounding Jupiter's orbit which may extend throughout the plane. The above conditions are approximately satisfied for the small planets (167) Urda, (243) Ida, and (396) whose mean motion is near $1+3/2$ and whose eccentricities and inclinations are very small; the planet (188) Menippo has a mean motion near 5/2, but an inclination and an eccentricity too large for these considerations to be immediately applicable. Kobb has called the attention of astronomers to the fact that he found the orbit of (153) Hilda to be stable but that the conditions for stability are not satisfied by the motion of (279) Thule; the same writer has shown the motion of the seventh satellite of Jupiter to be stable and that of the eighth unstable, while Moulton has established limits of temporary stability for satellite motion. Levi-Civita's criteria have been studied by Cigala, and those of Lehmann-Filhés for circular motion have been generalized by Frank. Gray has given a résumé of the work of Charlier, Hill, Picart, Roche and Schiaparelli on the stability of a swarm of meteorites and of a planet and satellite, and Routh has discussed the motion and stability of a swarm of particles whose center of gravity describes an elliptic orbit of small eccentricity about the sun. Considering a system composed of a planet, a rigid ring, and a satellite Bohl has proved that under certain initial conditions the motion can be terminated only by a ring planet collision; further, that the possibility of the latter collision may be excluded and permanent stability secured.

The new methods in celestial mechanics have proved their usefulness in computing the perturbations of those small planets whose period of revolution is approximately commensurable with that of Jupiter. To enumerate: Simonin has applied Poincaré's methods to the case of Hecuba and has succeeded in obtaining a very close solution by means of simple expressions; Hill has devoted two memoirs to examples of periodic solution in studies primarily concerned with cases of mean motions respectively triple and double (Hecuba type) that of Jupiter; Poincaré has shown the essential agreement between his own results and those of Brendel's "Theorie der kleinen Planeten" constructed along the lines of Gyldén's method; Hill and Andoyer have applied Delaunay's method to the Hecuba group; Poincaré has exhibited the relations of Simonin's results to the applications of Gyldén's method made by Ludendorff to Hecuba, by Brendel to Hestia, and by Harzer to Hecuba; Schwarzschild has made a numerical investigation of periodic solutions in the vicinity of the Hecuba orbit; Wilkens has applied his asymmetric solutions to orbits of the Hecuba type, establishing their stability by Poincaré's method; and finally Wilkens and De Sitter have studied solutions of the Hestia type. A class of periodic solutions was designed by Moulton, and successfully applied to the lunar theory; independently Gyldén and Moulton utilized periodic orbits to explain the Gegenschein; and McCallie, following a suggestion of Hill's, constructed an example of periodic solutions from the theory of Jupiter and Saturn. Strömgren found that asymptotic motion towards one of the equilateral triangular centers of libration takes place only under exceptional circumstances, for as a rule the body describes a periodic orbit around this center or recedes indefinitely from it.

In an exhaustive treatment including all the limitation and libration motions of the special case of the three-body problem when two of the bodies are fixed Charlier has noted two applications: first to the case where a small body passes at great speed through a double star system, and second

to the generalization of those conditions which result in the moon revolving about the sun if the earth and sun become fixed centers. Charlier has also considered the relations of the two-body problem to the two-center problem, and has pointed out the advantages of solutions of the latter as intermediate orbits in the asteroid problem. The case where one fixed center attracts and the other repels was worked out in detail by Wöller; and Hiltebeitel applied the method of Charlier's work to the qualitative discussion of the most general two-center problem admitting of separation of the variables.

Hill has prepared a number of examples of Gyldén's periplegmatic orbits, some of which are periodic. The construction of the solutions calls for elliptic functions, Lindstedt's series, and sequences of Delaunay transformations. These examples of Hill have been generalized in several directions, in one of which certain of Painlevé's new transcendental functions find application. For the case of two nearly equal bodies and a third infinitesimal body Pavannini found a new category of periodic solutions which have been extended to the restricted problem of four bodies. Andoyer's memoir on the relative equilibrium of n bodies has been made by him the basis of a study of periodic solutions in the vicinity of positions of relative equilibrium under forces varying as the masses and any power of the distances. Longley has constructed the only orbits (one direct the other retrograde) of preassigned period in the plane n-body problem which consist of an infinitesimal body revolving around one of $n-1$ finite masses which are in periodic motion. For the plane n-body problem having the same distribution of masses as the solar system, Griffin found a class of periodic solutions of which he has made numerical application to the three inner satellites of Jupiter.

FORMAL AND QUALITATIVE RESOLUTION OF THE PROBLEM

By generalizing somewhat the theory of periodic and asymptotic solutions by which Poincaré established the divergence of Lindstedt's series von Zeipel has been able to study the series, however great the mutual inclination of the orbits may be. He derived the following necessary and sufficient conditions for the existence of the series: first, that the orbits be nearly circular; second, that a certain biquadratic equation have real and unequal roots. Von Zeipel found that if the inclination of an asteroid exceeds a certain limit (about 30°, slightly variable) the series of Lindstedt cease to exist; and he remarked that it is perhaps permissible to see in this theorem, although Lindstedt's series are only semi-convergent, the cause of the surprising fact that among five hundred asteroids there exists but one (Pallas) whose inclination exceeds 30°.

Hill has extended Delaunay's method to the general problem of planetary motion, and, employing the fundamental conceptions of Gyldén, he has indicated a practicable way for its application, in two memoirs on integrals of planetary motion, suitable for an indefinite length of time. Charlier has discussed the properties of the general solution in trigonometric series by supposing it to have been derived from the integration of the Hamilton-Jacobi equation. For constructing solutions in the form of trigonometric series, Whittaker has devised a method, closely analogous to Delaunay's, and consisting essentially in the repeated application of contact transformations which ultimately reduce the problem to the equilibrium problem. Bohlin has just published the concluding memoirs of a remarkable series of investigations which have culminated in a non-existence theorem quoted in a previous paragraph, and in his new astronomical series for the distances

and coordinates; these series, both in their terms and in their coefficients, are built up from certain developments which Bohlin has derived for roots of the fundamental quintic met with in Lagrange's problem of the mutual distances.

The question of the validity of certain methods of Gyldén has been the source of considerable discussion among mathematical astronomers during the period under review. The appearance of a long memoir by Buchholz on Gyldén's horistic method, and its convergence, brought forth from Backlund a protest against the manner in which the material of the memoir had been accumulated and presented. To this protest Buchholz replied with a defense of the course he had pursued in preparing the work; and a little later he published another note objecting to a statement by Schwarzschild that Poincaré, in his prize memoir, had proved the divergency of the series employed by astronomers. About this time Poincaré examined in detail the second of Gyldén's two horistic methods, the first being open to grave objections as had been shown by himself and Backlund. As a result of his investigation Poincaré found that the second method, conveniently modified, is a legitimate one, not for the search of the general solution, but for the determination of one of those particular solutions which he himself had termed periodic. He pronounced futile the effort to derive from the horistic method developments uniformly convergent in the geometric sense of the word, and declared false Gyldén's conclusion that the terms of high order in the perturbative function can never produce libration. Poincaré's results were questioned by Backlund and an interesting controversy ensued, some points of which were elaborated upon in a later extensive memoir which Poincaré devoted to Gyldén's theory, where he pointed out Gyldén's great service to science in creating a number of new methods which have been applied with success to certain problems of mathematical astronomy, as for instance, in the theory of the small planets developed by Harzer and Brendel. He found the methods proposed in Gyldén's earlier memoirs to be correct in the main, but possessed of little more than historic interest, having been superseded by less inconvenient methods such as those of Hill and Brown. Gyldén's later theories Poincaré subjected page by page to a searching critical examination which resulted in a declaration that they are invalidated throughout by errors arising in the initial stages of Gyldén's analysis.

Thanks to the recent researches of Levi-Civita, Bisconcini, Sundman and Block, inspired as they were by an earlier theorem of Painlevé the qualitative solution has been attained in the field of the formal resolution of the mathematical problem of three bodies, and some progress has been made towards the same end in the astronomical problem. Painlevé demonstrated that starting from given initial conditions singularities occur only if one at least of the mutual distances tends towards zero, when t converges to a finite value t_1. When these singularities have been located, the recent theorems of Mittag-Leffler, on the representation of monogenic branches of analytical functions, warrant the assertion that the coordinates are expressible in every case, and throughout the duration of the motion, in series possessing the fundamental properties of Taylor's series. It may be remarked in passing that Volterra has given examples of the applicability of Mittag-Leffler's developments to certain cases of the general n-body problem. From the standpoint of the qualitative resolution of the problem, it becomes of paramount importance, then, to define with precision the initial conditions which lead to a collision. Painlevé in his Stockholm

lectures announced the opinion that the initial conditions which constrain a collision of at least two of the three bodies at the end of a finite time, satisfy two distinct analytical relations, which reduce to one in the case of plane motion. These analytical relations whose existence Painlevé divined have been disclosed by the brilliant researches of the two Italian mathematicians, Levi-Civita and Bisconcini. Levi-Civita blazed the trail in the restricted problem and found an unique, invariant relation, algebraical in the velocities, periodic and uniform, which he developed in a power series. It may be noted that simple modifications of Levi-Civita's analysis render it immediately applicable to the restricted problem of four bodies. There appears again a single uniform periodic condition for collisions of two of the bodies, and this condition is algebraic in the velocities. The result thus constitutes an exception to Painlevé's theorem that when three of the masses are different from zero the conditions which must be satisfied in the n-body problem in order that after a finite interval of time two of the bodies may collide, can not be *algebraical conditions*. In the general three-body problem Bisconcini, following the route marked out by Levi-Civita in the restricted problem, has arrived at two distinct relations whose analytical form he has determined. Bisconcini has thus been able to characterize all the singular motions of the system in which any two of the bodies collide, and to determine the analytical conditions under which we may be certain that the motion will proceed regularly. One of the assumptions made by Bisconcini in the course of this work has since been demonstrated by Sundman. In a new elaboration of his original memoir Levi-Civita has been able to extend certain of his results to the astronomical, restricted problem. Sundman has found the condition for the simultaneous collision of all three bodies to consist in a vanishing of all three integrals of areas in the motion of the bodies with respect to their common center of gravity; if the constants of areas are not all zero, Sundman has assigned a positive limit below which, of the three distances, the greatest always remains so. The same writer has announced the extension of his results to the n-body problem, including explicit expressions for the coordinates in the vicinity of equilibrium. In the meantime Block has presented to the Swedish Academy of Sciences a memoir in which he has given the developments in powers of the time in Sundman's case of collision; these power series contain terms of three different forms in whose exponents the masses of the bodies appear. The recent memoirs of von Zeipel on intransitive motion in the three-body problem and the indeterminate singularities in the case of n bodies are treated in the report reviewed here. Mittag-Leffler is preparing a memoir soon to be published in the *Acta Mathematica* in which there will appear a digest of Weierstrass's correspondence in its bearing on the problem of three bodies. The memoir will be concerned especially with the relations of this correspondence to the setting of the problem for the prize, offered by the late King Oscar II., of Sweden; to the report on which the award of the prize was based; and to the recent work on the singular trajectories of the general problem of three bodies, and its resolution in power series.

V

GENERALIZATIONS OF THE PROBLEM AND ITS INVERSION

During the period under discussion the problem has been variously generalized. Ebert has formulated an equivalent problem to that of n bodies, with an additional integral; and a similar generalization has been made by extending the Bour-Bertrand

treatment of the three-body problem. Esclagnon and Bohl have indicated applications of quasi-periodic functions to the ordinary problem; special cases in which the masses vary with the time have been considered by Mestchersky; Laves has studied the integrals when the forces depend upon the coordinates and their derivatives of the first two orders; and Ebert has taken up the problem in space of any number of dimensions.

Bertrand inverted the problem of two bodies by proposing to find the law of force under which a body, whatever may be its initial position and velocity, always describes a conic section. This inverse problem was solved independently by Bertrand, Darboux and Halphén; and extended by Dainelli to general curve trajectories. Stephanos has recently given another generalization of Bertrand's problem by including in the discussion the case in which the force has not necessarily an unique direction at every point of the conic section. This problem in turn has been generalized to conditions which include the conic section trajectories as special cases. Griffin observed that the law of force under which a given curve is described as a central orbit can not be determined uniquely if only the position of the center of force be known. Oppenheim gave to Bertrand's problem a new treatment which included the case of finding the central conservative forces under which three bodies of arbitrary mass describe given plane curves.

A further generalization of Bertrand's problem presents itself in the problem of finding the forces of a central conservative system capable of maintaining a system of m particles on as many prescribed but arbitrary orbits in a space of n dimensions. The resolution of this problem shows that the central conservative character of the motion and the equations of the orbits are necessary and sufficient to determine the components of the velocities, only in the case of $\frac{1}{2}n(n+1)$ bodies, and the components of the forces only in that of $2n-1$ bodies. From this point of view the plane three-body problem possesses an unique generality of its own, in that it is the only case in which all the elements of the mechanics of the problem are completely determinate when the arbitrary plane curves described by the bodies under central conservative forces are given. This circumstance has been turned to account in the construction of new integrable problems of three bodies under laws of force involving only the masses and the mutual distances of the bodies.

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THE PHYLETIC IDEA IN TAXONOMY[1]

TO-DAY every botanist is an evolutionist. It may well be that we have not yet agreed as to the details—as to the particular manner in which modifications were effected—whether they were by slow and almost imperceptible deviations from the parental type, or those more marked variations that we are in the habit to-day of calling "mutants." Some of us may lay more stress upon the "survival of the fittest," others upon the "survival of the unlike." For some the "struggle for existence" may account for the diversity of plant forms, while others see in "adaptation" the explanation of the same diversity. To some the "inherent tendency" in plants to vary is a potent factor, while for others all variation is a result of "environment." Yet with all this diversity of opinion as to details there is a practical unanimity as to the acceptance of the general doctrine of evolution. It may be asserted without fear

[1] Address of the vice-president and chairman of Section G—Botany—of the American Association for the Advancement of Science, Baltimore, 1908.

of contradiction that all scientific botanists hold that the vegetable kingdom as we know it to-day is the result of a series of evolutions from lower to higher types of plants, and that every higher plant owes its present structure to the favorable modification of some ancestral lower plant. To-day when we study the particular structure of any plant we consider it to be the result of the modifications that have taken place in its phylogenetic history. No botanist now considers a species to be a separate or special creation, but rather a more or less distinguishable variation from some other form.

With such an agreement among botanists as to the validity of the doctrine of evolution, it needs no argument to sustain the thesis that a natural classification must be an expression of a theory of evolution. Such taxonomic terms as "higher," "lower," "primitive," "derived," "relationship," "affinity," etc., can have no other significance than that given them by the doctrine of evolution. To-day there are no hidden or occult meanings to be attached to plant structures. We no longer credit the doctrine of signatures, whether in medical or systematic botany. We no longer seek to find the characters which in some mysterious way are the special marks of classes, nor those which are necessarily ordinal marks, or the characteristic marks of families, and so on to genera and species. And yet it is not so very long since a great biologist seriously set about trying to do this very thing. You will remember that Agassiz made this attempt[2] about fifty years ago, and that he actually formulated his plan in definite terms. I may as well quote the paragraphs in which he states his method of characterizing different groups. They are as follows:

> *Branches* or *types* are characterized by the plan of their structures;
> *Classes*, by the manner in which that plan is executed, as far as ways and means are concerned;
> *Orders*, by the degrees of complication of that structure;
> *Families*, by their form, as far as determined by structure;
> *Genera*, by the details of the execution in special parts; and
> *Species*, by the relations of individuals to one another and to the world in which they live, as well as by the proportions of their parts, their ornamentation, etc.

With regard to these he says a little later[3] that "the branches, the classes, the orders, the families, the genera, the species, are groups established in nature respectively upon different categories," and declares that he feels "prepared to trace the natural limits of these groups by the characteristic features upon which they are founded," that is, upon those which have just been enumerated in my quotation.

In the common systematic characters as drawn up by many botanists in the recent past there has been something of the old-time notion that we are dealing with fixed groups whose limits are indicated to us by certain rather definite structural characters which nature has accommodatingly attached to all plants in these groups. The thought seems to have been that plants are "tagged" or "branded" with the peculiar marks of the group, these marks having otherwise no particular significance. One is reminded of the similar use which stockmen on the plains make of arbitrary names, monograms or hieroglyphics for indicating what animals belong to this or that particular ranch. And it appears that this view of the meaning of taxonomy and the significance of characters has not wholly died out. The most reasonable explanation of the inordinate species making practised by some botanists is that they are still under

[2] "An Essay on Classification," by Louis Agassiz, London. The preface dated December, 1858, p 261.

[3] "An Essay on Classification," p. 263.

the dominance of the old doctrine of the fixity and inviolability of characters, especially the characters of species. When one holds this view it is very easy for him to find in every variation the indication of a new species, for all one must do is to find that every varietal character is really specific according to such rules as those laid down above by Agassiz. One may logically hold that if characters of a particular kind are of "specific" value, they must be valid, however faint or obscure they may be. Probably the recently observed activity in the making of new species is the flickering of the dying flame of this expiring theory. Wholly inconsistent with the doctrine of evolution, it must soon die out, and we may well be patient while it lasts, praying in the meantime that its final happy extinction may not be long delayed.

I need scarcely refer here to the "map theory" of relationship which was once quite the vogue, and of which remnants are still to be seen in some charts showing the relationships of groups. In some of these we still see an attempt to indicate the genetic relationship of a particular group in more than two directions! Before the general acceptance of the doctrine of evolution such an indication of relationship was quite consistent, for into taxonomy no definite conception of genetic relationship had yet entered. Groups of plants were thought of as related to one another, as we think of the relationship of one state to another on a map. And no doubt it was a helpful device for giving clearer notions of the similarities between plant groups. Just as the children in the schools learned much by the exercise of "bounding" the states, so it was profitable in those ante-evolutionary days to use these imaginary maps to show similarities by nearness or juxtaposition. Yet while the practise may once have been profitable, it is no longer so, and to engraft genetic ideas upon it is really quite impossible.

There is still another conception of plant taxonomy to which I must advert, namely, the philosophical division of the vegetable kingdom into convenient groups of various grades, as divisions, subdivisions, classes, subclasses, orders, suborders, etc. Such groups are in a sense natural, in that they are usually characterized by structures which are conceived to have been evolved from others somewhat like them. Yet these have failed to commend themselves permanently, no doubt because generally they have been based upon only one or at best a few closely related characters. Thus the somewhat recent attempt to divide the vegetable kingdom into Protophytes and Metaphytes is an apt illustration, as is also its earlier division into Phanerogams and Cryptogams. And of like nature was the suggestion to divide the dicotyledonous plants into Chalazogamae and Porogamae. The proposal made by Sachs to divide the Thallophytes into Zygosporeae, Oosporeae and Carposporeae, while no doubt it did much to dispel the confusion with regard to the plants included, failed to commend itself generally because it separated clearly related groups of plants. The failure of this arrangement was due not so much to the fact that it was based upon one character—namely, the mode of sexual reproduction—as to the far more important fact that it took practically no account of the evolution of the plants constituting the groups. Herein was its weakness, and in spite of the advantage of clearness and ease of understanding which it possessed to a marked degree, it was never adopted by systematic botanists.

A few columns back I said that a natural classification must be an expression of a theory of evolution. I will go farther now and say that it is sound scientific practise

to change our classification when we change our theory of evolution. This follows logically as a corollary of the main thesis, but it is well to place our acceptance of it on record, lest in our zeal for consistency we may neglect it. No system of classification should stand in its entirety after the theory of evolution upon which it is based has experienced any change whatever. The two must be modified simultaneously, for they are parts of a common system.

What does the theory of evolution involve to-day? It will be well to pause here for a short enumeration of the principal features of this theory so far as they bear upon the question of classification. I need scarcely remind you that for the purposes of this discussion it is not necessary to decide between the different schools of evolutionists, since their differences are almost wholly of such nature as to have little or no bearing upon a system of plant taxonomy.

Elsewhere[4] I have enumerated the following dicta as involved in the theory of evolution as applied to the vegetable kingdom:

1. In general the lower plants came into existence first.
2. In general the higher plants sprang from the lower.
3. Higher plants are more complex than the lower.
4. Structures with many similar parts (homogeneous) are lower, those with fewer and dissimilar parts (heterogeneous) are higher.
5. Evolution is not always upward, but often involves degradation and degeneration.
6. Evolution does not necessarily involve all organs of the plant equally in any particular period.
7. One organ of a plant may be advancing while another is retrograding.
8. Upward development is sometimes through an increase in complexity, and sometimes by a simplification of an organ or a set of organs.
9. In some cases particular structures become more simple while the plants themselves become more complex.
10. Evolution has generally been consistent, and when a particular progression or retrogression has set in it is persisted in to the end of the phylum.
11. Retrogression, once set in, usually persists, and is not followed by a progression.
12. Hysterophytic degeneration is persistent, and the hysterophytic phylum never becomes holophytic.
13. In the first stages in the development of any organ, whether upward or downward, the new structures are not as fixed as they become later, and in these earlier conditions there may be reversions to the ancestral structures, while later such reversions do not occur.
14. All plant relationships are genetic.
15. Plants are related *up and down* the genetic lines, and the system of plants to be quite natural must recognize these phyla.

While these fifteen dicta are by no means all that might be cited, they will suffice for my present purpose. From them the phyletic idea in taxonomy follows logically. Since all natural groups must be phyletic, only that arrangement is natural that recognizes these in their entirety. It should no longer be permissible on scientific grounds to propose a classification which is not phyletic.

We may now profitably inquire as to the origin of phyla, and to seek an answer as far as it is possible to find one in general terms and on theoretic grounds. Stated philosophically, from what we know of the relationship of organic beings it is obvious that a phylum originates with the incoming of a new idea. Stated structurally, it has its beginning with the development of a dominant morphological peculiarity. Stated taxonomically, its initial point is indicated by the appearance of a new character.

Every phylum is the result of a development which differs from that which preceded it because of the incoming of a new dominant idea. This dominant idea was manifested structually by a divergence

[4] "A Synopsis of Plant Phyla," *University of Nebraska Studies*, October, 1907, p. 1.

from the previous lines of evolution, and this point of divergence is the actual origin of the new phylum. As far as this idea dominates, so far does the phylum extend, and when a still newer idea comes in and attains dominance, a still newer phylum has its beginning.

In this manner may we mark the beginning and the extent of phyla. They originate with a divergence which is the expression of a new idea. It is what we often call a "tendency." In taxonomy we refer to it as a "new character," this latter term being sometimes somewhat confusingly applied to the underlying idea and sometimes to its obvious structural expression.

The result of the successive development of phyla is quite like that in a tree where newer branches spring from older ones by the formation of buds, from which branches develop in succession. And as there are branches of all grades, from the primitive diverging growths which eventually divide the tree profoundly into great segments, through the smaller and smaller branches to the very recent slender twigs—the growths of but yesterday—so it is with the development of successive phyla from one another, the result being a complex tree-like aggregation with older phyla below and younger and smaller phyla above.

In order to discern phyla, the botanist must certainly be familiar with the whole vegetable kingdom, or at the least with the great region in which the particular phyla under consideration occur. He must be able to bring to mind the families, genera and species of plants with such clearness as will enable him to see the direction of the evolutionary current—the "drift" of evolution in the vegetable kingdom as a whole, and in the particular portion immediately under his consideration. I know that this is often a difficult task, just as it may be very difficult to determine the direction of the water current in a lake by observations at one point only: yet it may be very easy when the points of observation are multiplied. So it is here difficult, and perhaps impossible, for the man whose point of view is limited to a small portion of the botanical shore-line. The trained eye of the experienced man can catch the drift of the waters from a few properly selected points of observation, and likewise the trained eye of the botanist from observations at properly selected stations may detect the direction of evolutionary progress, as well as the origin and extent of the resulting phyla.

Applying what has been suggested in the foregoing brief and somewhat desultory discussion, it appears to me that we may recognize the following plant phyla of primary rank:

1. *Myxophyceae,* in which the dominant idea is the simple nucleus, typically not limited by a nuclear membrane. The simple plant body, of one or only a few cells, the blue-green diffused pigment, and the soft and often gelatinous walls may be regarded as characters of secondary importance.

Here are included also many hysterophytes (bacteria) which I regard as degenerates from the normal plants of this phylum.

Probably from the highest *Myxophyceae* came the second phylum—

2. *Protophyceae,* in which the dominant idea is the definite nucleus, limited by a nuclear membrane. The simple plant body of one cell or of a repetition of mostly similar cells, the typically motile, ciliated gametes, the definite chromatophores carrying a chlorophyll-green pigment, and the usually firm cell wall, are limiting secondary characters.

I here include *Pleurococcaceae, Ulvaceae, Ulotrichaceae, Oedogoniaceae, Coleochae-*

taceae, and a dozen or so related families. This phylum has been unusually productive of other phyla of primary and secondary rank, and elsewhere[5] I have hazarded the suggestion that from the lower *Protophyceae* (near *Protococcoideae*) a phyletic line passed off and gave rise to the animal kingdom.

Springing from the filamentous *Protophyceae* is the third phylum—

3. *Zygophyceae,* in which the sluggish cells easily separate, and the non-ciliated gametes move feebly. This is a phylum on the down-grade, and all of its members show structural degeneration. In the desmids and diatoms the filaments usually separate early into single cells, resulting in the so-called "unicellular" structure of these plants.

The filamentous pondscums (*Spirogyraceae, Zygnemataceae* and *Mesocarpaceae*) are here held to have given rise by early fragmentation to several secondary phyla, including the three families of desmids, and the many families of diatoms.

From the filamentous *Protophyceae* there came also the fourth phylum—

4. *Siphonophyceae,* in which the dominant idea is the development of coenocytes. The retention of the typically motile ciliated gametes producing simple zygotes upon uniting, the chlorophyll-green chromatophores, and the mostly filamentous or upright plant body which is rooted below, are important secondary characters.

Beginning with the segmented *Cladophoraceae* two secondary phyla may be recognized—one (*Vaucherioideae*) of filamentous plants—the other (*Bryopsidoideae*) of upright and branched plants. Many species have degenerated into hysterophytes.

Again, from the filamentous *Protophyceae* came the fifth phylum—

5. *Phaeophyceae,* in which the dominant feature is the addition of the brown pigment (phycophaein) to the chlorophyll of the cells. The typically motile, ciliated gametes, producing simple zygotes upon uniting, and the filamentous to massive plant body, rooted below, are secondary limiting characters.

Starting with the filamentous and often small *Ectocarpaceae,* this group readily divides itself into two well-marked secondary phyla—*Phaeosporeae,* and *Cyclosporeae,* the former culminating in the gigantic *Laminariaceae,* and the latter in the highly developed *Sargassaceae.*

Going back again to the fertile group of the filamentous *Protophyceae,* we find the origin of the sixth phylum—

6. *Carpophyceae,* whose dominant characters are the reddish pigment (phycoerythrin) added to the chlorophyll of the cells, and the growth of the zygote into a spore-fruit. The mostly erect, symmetrically branched and basally-rooted plant body, and the definite attainment of heterogamy, afford important secondary characters.

Here the typically marine *Bangioideae* and *Florideae* dominate the phylum, and these develop phycoerythrin in their cells, while the green fresh-water *Charoideae* constitute a small side line.

From the more primitive, probably filamentous *Carpophyceae* came the seventh phylum—

7. *Carpomyceteae,* whose dominant idea is the abandonment of the holophytic habit, and the adoption of the hysterophytic habit, with the disappearance of chlorophyll, resulting in the atrophy of the vegetative portions of the plant body and the increase in reproductive structures.

[5] "The Structure and Classification of the Lower Green Algæ," in *Trans. Am. Mic. Society,* Vol. XXVI., 1905, pp. 121–136; and later in "A Synopsis of Plant Phyla," 1907. See also my "Essentials of Botany," sixth edition, 1896, pp. 137–8.

The spore-fruit inherited from the preceding phylum undergoes many changes and is often degenerated, and this sometimes involves the gametes themselves.

This phylum is one of marked departure from the general upgrade evolution in the vegetable kingdom, and its successive smaller phyla show increasing degeneration in the structure of the plant body, which in the rusts and smuts becomes excessive, while in some cup-fungi (*Pezizales* and *Helvellales*), puff-balls (*Lycoperdales*) and toadstools (*Hymenomycetales*) the spore fruit is relatively very large.

From the higher *Protophyceae* (probably near Coleochaetales) came the eighth phylum—

8. *Bryophyta,* in which the dominant idea is the growth of the zygote into an alternate, short-lived generation, the sporophyte, and the consequent adoption of the land habit.

The two secondary phyla are *Hepaticae* and *Musci.*

From the lower *Bryophyta* (probably near *Anthocerotales*) came the ninth phylum—

9. *Pteridophyta,* whose dominant character is the growth of massive roots and broad leaves upon the sporophyte, rendering it long-lived and independent, and resulting in the postponement of spore formation.

It must be noted here that I use the term *Pteridophyta* in the narrower sense, limiting it to ferns (*Filicinae*) and excluding lycopods and horsetails. The incoming of heterospory in some ferns is a significant fact.

From the lower *Pteridophyta* (probably near *Ophioglossales*) came the tenth phylum—

10. *Lepidophyta,* in which the dominant character is the long-lived, erect cylindrical stem of the sporophyte, which bears massive roots below, is covered with many small scattered leaves, and terminates in a strobilus of imbricated sporophylls above.

From the lower *Pteridophyta* again (probably near *Ophioglossales*) came the eleventh phylum—

11. *Calamophyta,* in which the dominant character is the long-lived, erect, cylindrical stem of the sporophyte, which bears massive roots below, regularly whorled leaves and branches, and terminates in a strobilus of whorled sporophylls.

In the two preceding phyla, heterospory, although present, has not yet become fixed. In both the increased definiteness of the strobilus is significant.

From other lower *Pteridophyta* (near *Marattiales* of *Isoetales*) came the twelfth phylum—

12. *Cycadophyta,* in which the dominant idea is the uniform production of heterospores in simple strobili of open sporophylls, upon the megaphyllous, spongy-wooded sporophyte, and the permanent retention of the megaspore in the sporangium, thus forming the seed.

I here include not only the cycads proper (*Cycadineae*), but also the much more primitive "seed ferns" (*Cycadofilices*), the ancestral conifers (*Cordaitineae*), the ancestral flowering plants (*Bennettitineae*), and the maiden-hair trees (*Ginkgoineae*).

From *Cycadophyta* came the—

13. *Gnetales,* if indeed they are not to be regarded as belonging to that phylum.

The three genera are doubtless the surviving remnants of former rather well developed secondary phyla, now nearly extinct.[6]

From the *Cycadophyta* came the fourteenth phylum—

14. *Strobilophyta,* in which the dominant idea is the development of definite,

[6] Consult here Arber and Parkin's paper on the Gnetales, in *Annals of Botany,* Vol. XXI. (1908), p. 489.

compact strobili of open microsporophylls and megasporophylls upon the microphyllous, solid-woody sporophyte.

I regard the cone-bearers proper—*Taxodiaceae, Araucariaceae, Abietaceae, Cupressaceae,* etc., as more primitive, and that from these have sprung such specialized forms as *Podocarpaceae, Phyllocladaceae* and *Taxaceae.*

From the *Cycadophyta* came also the fifteenth phylum—

15. *Anthophyta,* in which the dominant idea is the closure of the megasporophyll, and the transformation of the plain strobilus into the ornamental flower.

I am very glad to be able to suggest the restoration of the wholly appropriate name —*Anthophyta*—for this phylum. As I conceive this immense group, it is rather sharply divided into three secondary phyla which diverge from a common point of beginning—the so-called "Ranalian plexus." Two of these secondary phyla are dicotyledonous, while the third is monocotyledonous. The first culminates in the mints (*Lamiales*), the second in the sunflowers (*Asterales*) and the third in the orchids (*Orchidales*).

With regard to the relationship of the four phyla last named many facts have been brought to light during the past few years, which have quite materially modified the generally prevailing theories. With the publication of Wieland's epoch-making book on American cycads[7] attention has been centered upon the primitive cycads as the group of gymnosperms from which the angiosperms must have sprung. It is no longer a tenable hypothesis that the conifers are allied to the Amentiferae, as has long been held by many botanists. It is no longer necessary to begin the phylogeny of angiosperms with apetalous forms so as to make easier the passage from Coniferae. In fact, for many years there have been those who held that apetalous plants are not primitive, but on the contrary have been derived from petalous forms by reduction. Sixty years ago or more Jussieu hinted at the real nature of apetalous plants[8] and suggested the primitive nature of the Ranales, and consistently placed the Compositae at the summit of his system.

In the vice-presidential address[9] which I had the honor of delivering before this section fifteen years ago, after a careful examination of the families in the so-called Apetalae the conclusion was reached that "when we search for families in the Apetalae which may satisfy the requirements of a primitive group from which the dicotyledons may have evolved, we find none which will serve our purpose." Following the hint of Jussieu, the attempt was made to distribute the apetalous families among polypetalous and gamopetalous orders. A revision of the monocotyledonous and dicotyledonous orders was made so as to bring the apocarpous families near the beginning (lowest) point. Thus the water-plantains (*Alismales*) were given the first (lowest) place among monocotyledons, and buttercups (*Ranales*) and roses (*Rosales*) similar places among dicotyledons. From the water plantains (*Alismales*) a phyletic line was traced through the lilies (*Liliales*) to the modified (simplified) calla lilies (*Aroidales*), palms (*Palmales*) and grasses (*Graminales*), which form lateral offshoots of the main line, and then onward from lilies (*Liliales*) through irises (*Iridales*) to orchids (*Orchidales*). In like manner a phyletic line was traced from buttercups (*Ranales*) to pinks (*Caryophyllales*), prim-

[7] "American Fossil Cycads," by G. R. Wieland, 1906.

[8] "The Elements of Botany," by Adrien de Jussieu; translated by Wilson, 1848, p. 543.

[9] *Proceedings* of the American Association for the Advancement of Science, Vol. XLII., 1893, p. 245.

roses (*Primulales*), phloxes (*Polemoniales*) to figworts (*Personales*) and mints (*Lamiales*). Another line was sketched from roses (*Rosales*) to umbelworts (*Umbellales*), madders (*Rubiales*) and sunflowers (*Asterales*). Certain details of that arrangement, as the disposition of *Celastrales* and *Sapindales*, and the retention of the *Choripetalae* and *Gamopetalae* as valid groups, were subsequently found to be erroneous, and were corrected, but in the main the system as then outlined has been sustained by subsequent careful studies of the families.

Two years later[10] this general arrangement was expanded so as to include brief characterizations of the orders, suborders and families, and in it the *Celastrales* and *Sapindales* were brought into the phyletic line extending from *Rosales* to *Asterales*, but the *Choripetalae* and *Gamopetalae* were still recognized as valid groups.

A year later, in an elementary textbook[11] the *Choripetalae* and *Gamopetalae* were abandoned as definite groups of angiospermous orders, since it is evident that gamopetaly has been attained independently in at least two phyletic lines.

In my presidential address[12] before the Botanical Society of America in 1897, the dicotyledons were arranged in "two somewhat diverging genetic lines or phyla, each beginning with apocarpous, hypogynous, choripetalous plants, and both attaining syncarpy and gamopetaly, one remaining hypogynous, the other becoming epigynous." A little later it is explained that "since gamopetaly has evidently been attained at more than one point, it is no longer desirable to retain the *Gamopetalae* as a distinct group."

The latest restatement of this arrangement of the flowering plants was published at the beginning of the present year in my "Synopsis of Plant Phyla,"[13] already referred to earlier in this address. In it many minor corrections were made, and some suggestions were hazarded as to the point of origin of angiosperms, and conifers. These suggestions followed the line sketched by Arber and Parkin in their paper on the "Origin of Angiosperms"[14] published a few months earlier. Basing their argument upon the discoveries of Wieland[15] these authors concluded that angiosperms were derived from Cycadean ancestors of the Bennettitean type, with an open flower-like strobilus ("pro-anthostrobilus") of megasporophylls, microsporophylls ("amphisporangiate") and asporophylls ("perianth"). As a consequence they arrive at the conclusion that primitive angiosperms were necessarily polypetalous, hypogynous and apocarpous, precisely the conclusion reached by me on theoretical grounds more than fifteen years ago, and since then persistently held in the face of the increasing popularity of Engler's system. It would now appear probable that there must soon be another rearrangement of the flowering plants. We have recently witnessed the almost complete inversion of the sequence of the families of flowering plants in our systematic manuals, and it appears now that we shall barely have time to become accustomed to the new order before we shall have to learn still another. It seems now inevitable that such orders as

[10] In Johnson's "Universal Cyclopedia," Vol. VIII. (1895).

[11] "The Essentials of Botany," sixth edition, 1896, p. 322.

[12] "The Phylogeny and Taxonomy of Angiosperms," August 17, 1897. Published in *Botanical Gazette*, Vol. XXIV., p. 145.

[13] "A Synopsis of Plant Phyla," in *University of Nebraska Studies*, October, 1907 (issued February, 1908).

[14] "The Origin of Angiosperms," by F. A. Newell Arber and John Parkin, in *Linnean Society's Journal—Botany*, Vol. XXXVIII., July, 1907.

[15] "American Fossil Cycads," 1906.

the buttercups (*Ranales*), water plantains (*Alismales*), and roses (*Rosales*) are to be regarded as primitive, and as a consequence they must stand at the beginning of the great phylum *Anthophyta*, as also each must stand at the beginning of its smaller phylum. That the phylum beginning with the water plantains (*Alismales*) must find its highest development in the irises (*Iridales*) and orchids (*Orchidales*) can not be doubted; nor can it be questioned that grasses (*Graminales*), calla lilies (*Aroidales*) and palms (*Palmales*) must now stand as reduced from the type of the lilies (*Liliales*). This leaves no room for radical differences of opinion, and in fact little room for any but the most minor differences in regard to the proper sequence of the monocotyledonous families.

In like manner beginning with the Ranalian type in the dicotyledons, it is obvious that one phyletic line culminates in the gamopetalous, bicarpellate, hypogynous order of the mints (*Lamiales*), while another passes through the roses (*Rosales*) (if indeed they are not themselves primitive), and umbelworts (*Umbellales*) to the sunflowers (*Asterales*). Here again, with regard to the details as to the intermediate orders there may be much difference of opinion. Yet there will be no question that in one line the pinks (*Caryophyllales*) and mallows (*Malvales*) are lower than primroses (*Primulales*) and heaths (*Ericales*), nor that the latter are lower than phloxes (*Polemoniales*) and mints (*Lamiales*). In the other line the myrtles (*Myrtales*) are clearly lower than umbelworts (*Umbellales*), while the latter are manifestly lower than madders (*Rubiales*), and these than sunflowers (*Asterales*). In fact when we agree to the hypothesis that polypetalous, hypogynous, apocarpous flowers are primitive the great outlines of the phylum (or phyla) are quite obvious, and the only questionable points are with reference to the place and sequence of intermediate orders. And it is here that much critical work invites the close attention of taxonomists. The great outlines—the boundaries of the phyla—are drawn, but the particular manner in which many of the interior families are related to each other has not yet been made out.

The principles here brought forward, and the general plan which I have so hastily sketched, have been so serviceable in the presentation of the subject of taxonomy in my lectures to university students that I venture to lay them before you as a general working hypothesis. My own success in its use encourages me in the hope that in the hands of others it may be equally helpful in enabling the student of taxonomy to more clearly apprehend the mode of evolution in the vegetable kingdom, and the consequent relationship of the resulting multiplicity of types.

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THE DARWIN CENTENARY AT CAMBRIDGE

Some details are given in the London *Times* of the celebration by the University of Cambridge of the centenary of the birth of Charles Darwin and the jubilee of the first publication of "The Origin of Species." It is expected that delegates selected by universities, academies, colleges and learned societies will arrive in Cambridge on Tuesday, June 22, and that the arrangements for their entertainment, which are, however, subject to alteration, will be as follows: On the evening of the twenty-second there will be a reception, probably in the Fitzwilliam Museum, by the chancellor. On Wednesday, June 23, addresses will be presented by the delegates to the university in the senate house. It is hoped to present to each delegate a copy of the first draft of "The Origin of Species." In the afternoon there will be a garden party at Christ's College, where Darwin was a stu-

dent, and in the evening the university will give a banquet. On Thursday, June 24, the Rede lecture will be delivered, and honorary degrees will be conferred. It is further proposed to hold an exhibition of portraits, editions and relics of Darwin at Christ's College, somewhat similar to the Milton exhibition of last June.

Already some 200 delegates have been appointed to represent institutions, including:

Professor W. G. Farlow, American Academy of Arts and Sciences, Boston; Professor C. S. Minot, Boston; Professor R. H. Chittenden, Yale University, New Haven; Professor E. B. Wilson, Columbia University, New York; Dr. J. M. Baldwin, Johns Hopkins University, Baltimore; Professor J. Loeb, University of California, Berkeley; Dr. H. F. Osborn, American Philosophical Society; Dr. L. O. Howard, Academy of Sciences, Washington; Mr. C. F. Cox, Academy of Sciences, New York; Domingo Gana, Universidad de Chile, Santiago; Hofrat Dr. L. von Graff, Gratz; Professor Vejdovsky, Prague; Hofrat Dr. F. Steindachner, Vienna; Professor E. van Beneden, Brussels; Professor H. F. E. Jungersen, Copenhagen; Professor Cuénot, Nancy; M. van Tieghem, Institute de France, Paris; Le Prince Roland Bonaparte, Institute de France, Paris; Professor E. Metchnikoff, Pasteur Institute, Paris; Ober-Regierungsrat Professor Adolf Engler, Deutsche Botanische Gesellschaft, Berlin; Dr. F. von Luschan, Gesellschaft für Anthropologie, Ethnologie und Urgeschichte, Berlin; Professor Kukenthal, Breslau; Professor Max Verworn, Göttingen; Professor Bütschli, Heidelberg; Professor R. Hertwig, Munich; Professor Goebel, Munich; Professor E. Ballowitz, Münster; Professor Graf zu Solms-Laubach, Strassburg; Professor Th. Boveri, Würzburg; Professor H. de Vries, Amsterdam; Professor J. H. van Bemmelen, Groningen; Professor A. A. W. Hubrecht, Utrecht; the Italian Ambassador, Marquis of San Giuliano, Società Geografica Italiana, Rome; Professor C. Ishikawa, Tokio; Dr. W. C. Brögger, Christiania; Professor V. M. Simkevic and Professor V. V. Zalenskij, St. Petersburg; Professor H. Théel, Professor Chr. Aurivillius and Professor A. G. Nathorst, Stockholm; Dr. Paul Sarasin, Zurich; the Right Hon. Sir John Buchanan, University of Cape of Good Hope, Cape Town; Sir Richard Solomon, University College, Johannesburg; Professor A. Liversidge, Royal Society of New South Wales, Sydney; Sir E. T. Candy, the University, Bombay; Sir Lewis Tupper, Panjab University, Lahore; Dr. J. C. Willis, Royal Botanic Gardens, Peradeniya; Professor E. Rutherford, Christchurch, New Zealand; Sir Oliver Lodge, Birmingham University; Sir Isambard Owen, Durham University; Dr. A. W. W. Dale, Liverpool University; Sir Archibald Geikie, the Royal Society, London; Lord Avebury, Sir T. Lauder Brunton and Sir E. Ray Lankester, the Royal Society, London; Mr. Francis Darwin, British Association for the Advancement of Science; the Duke of Northumberland, the Royal Institution, London; Sir James Crichton-Browne, the Royal Anthropological Institute, London; Lieutenant-Colonel D. Prain, Royal Botanic Gardens, Kew; Professor G. C. Bourne, Dr. F. Gotch and Professor E. B. Poulton, Oxford University; Sir Charles Eliot, Sheffield University; Mr. R. F. Scharff, Royal Zoological Society, Dublin; Professor W. C. McIntosh, St. Andrews University; Sir William Turner and Professor Cossar Ewart, Edinburgh University; Principal E. H. Griffiths, University College, Cardiff.

WOLCOTT GIBBS

THE death of Wolcott Gibbs takes a commanding figure from the ranks of the veterans of science. Attaining the age of over eighty-six years, he had been for a long time almost the sole survivor among the pioneers of American chemistry. He was one of the founders of the National Academy of Sciences in 1870; and he alone saw his name included among those of living members in 1908.

For over a decade he had headed in academic seniority the list of the faculties of Harvard University. He served there as Rumford professor for twenty-four years, and in honorable retirement bore the title of Rumford professor emeritus for twenty-one years more. The infirmity due to his increasing years had withdrawn from him the privilege of contributing to the growth of his beloved science; but his interest in the work of others remained keen and enthusiastic until the end had almost come—until pain had driven away all the joy of life.

It has been said that he was one of the pioneers of American chemistry. He was made assistant professor in New York at the age of twenty-six in 1848. His eager and energetic spirit and his thorough training

under the inspiring guidance of Rose, Rammelsberg, Liebig, Laurent, Dumas and Regnault had given him an insight into the possible future of chemistry which forbade his contentedly settling down into the mere routine of teaching. Thus at once he joined the then pitifully small band of Americans who sought to advance the bounds of knowledge.

It is impossible here to present a detailed survey of the greatly varied fields in which his work lay, but a brief sketch will give some idea of the activity of his scientific imagination. His first important research concerned the complex ammonia-cobalt compounds, one of the most interesting series among inorganic substances. This masterly work, conducted with the collaboration of F. A. Genth, shed much light upon the puzzling nature of complex compounds in general, and laid the foundation for one of the most elaborate of modern chemical theories. The following years (1861–4) saw him engaged upon a careful study of the platinum metals, upon which he was engaged when he accepted the call to Cambridge in 1863. Shortly afterward (1864) he published for the first time a description of his use of the voltaic current for depositing copper and nickel in such a manner that the deposited metals could be directly weighed—thus providing a simple and exact quantitative method for the analysis of substances containing these metals. The fact that a German, Luckow, afterwards stated that he had used the method for copper before Gibbs had used it, does not detract from the real originality of Gibbs's idea; for Luckow's work was wholly unknown to Gibbs.

From time to time throughout all Gibbs's long period of scientific activity there appeared papers from his pen describing other new and useful methods of quantitative analysis, many of which have been incorporated into the common analytical practise of to-day. For example, his sand-filtering device of 1867 may be said to have been a forerunner of the present admirable apparatus perfected by Gooch and Munroe.

Not long after coming to Harvard, Gibbs turned his attention to the precise use of the spectrometer in chemical investigation, and this work was continued in 1875. Throughout all this time the subject of his work with Genth was only half dormant in his mind, and occasional theoretical or experimental papers concerning the peculiar nature of cobaltamine compounds showed his devotion to his early choice.

Not content with the paradoxes and puzzles offered by these complex bases, or with the other abstruse subjects mentioned, he attacked in succeeding years the complex inorganic acids, composed of various combinations of tungstic, molybdic, phosphoric, arsenic, antimonic and vanadic acids. One can not help wishing, upon studying his patient and careful quest among the bewildering phenomena manifested by these singular substances, that he had had the assistance of modern physical chemistry. But our present knowledge was not then at any one's disposal, and Gibbs did his best with the means at his command, devoting himself for a number of years to the expansion and systematizing of the work in this but slightly cultivated field.

From inorganic chemistry he later turned for a short time to a very different subject, undertaking with H. A. Hare and E. T. Reichert, a systematic study of the action of definitely related chemical compounds upon animals. This research, which appeared in 1891 and 1892, together with occasional previous papers upon organic chemistry, afforded evidence of the breadth of his interest.

Keen as his sense of the importance of physiological chemistry became, it was not keen enough to divert him wholly from his devotion to the rarer substances of the inorganic world, as his following paper on the oxides contained in cerite, samarskite, gadolinite and fergusonite testified.

Although Wolcott Gibbs was essentially an experimentalist, he was one of the first of American chemists to appreciate the importance of thermodynamics. His large library contained all the standard works upon heat, and his influence was the prime factor in having caused the award of the Rumford

medal to J. Willard Gibbs as early as 1880, long before the world at large appreciated the fundamental character of the work of the great New Haven physicist. Wolcott Gibbs served on the Rumford Committee of the American Academy for thirty years (1864–94), and in many other ways did his best to aid the progress of science in America. He was for a time president of the National Academy of Sciences, until ill health enforced his resignation; and he served also as president of the American Association for the Advancement of Science.

Not only at home, but also abroad, his eminence was worthily recognized. His election to honorary membership in the German Chemical Society in 1883 and, to corresponding membership in the Royal Prussian Academy in 1885 is perhaps the most striking evidence of the foreign appreciation of his work. No other American chemist has ever attained to either of these high honors.

The brief autobiography published in the issue of SCIENCE for Friday, December 18, makes unnecessary a repetition of the chief events in his quiet daily life. His manhood was spent partly in New York, partly in Cambridge, and finally during recent years, among his cherished flowers at his home on Gibbs Avenue near the First Beach at Newport, R. I. The circumstances of his early academic life brought him into close contact with but few students. This is the more to be regretted because his enthusiastic spirit, his tireless energy, his generous recognition of everything good, and best of all his warm human friendship endeared him to all who knew him. Those who were thus fortunate, whether students or colleagues, will always devotedly treasure his memory; and his place as a pioneer of science in America will always be secure.

THEODORE WILLIAM RICHARDS

SCIENTIFIC NOTES AND NEWS

THE honorary local secretaries of the British Association for the Advancement of Science to be held in Winnipeg from August 25 to September 1, of the present year, are C. M. Bell, Esq., W. Sanford Evans, Esq., Professor M. A. Parker. Enquiries and communications on matters connected with the meeting should be addressed: To the Local Secretaries, British Association for the Advancement of Science, University Building, Winnipeg, Man.

THE American Society of Zoologists, Eastern Branch, at its recent meeting in Baltimore, elected the following officers: *President,* Professor Herbert S. Jennings, the Johns Hopkins University; *Vice-president,* Professor H. V. Wilson, University of North Carolina; *Secretary-treasurer,* Dr. Lorande Loss Woodruff, Yale University; *Member of Executive Committee,* Professor Maynard M. Metcalf, Oberlin College.

A DIVISION of Food and Agricultural Chemistry of the American Chemical Society has organized and elected the following officers and executive committee: *Chairman,* W. D. Bigelow; *Vice-chairman,* C. A. Brown; *Secretary,* W. B. D. Penniman; *Executive Committee,* F. K. Cameron, H. H. Huston, P. Rudnich, B. E. Curry.

AT the annual meeting of the Academy of Science of St. Louis, Professor Trelease was elected president, and Professor McCourt, recording secretary, for the current year.

PRESIDENT JAMES B. ANGELL, of the University of Michigan, celebrated his eightieth birthday on January 7, while attending the meeting of the Association of American Universities, at Cornell University.

PRESIDENT ELIOT, of Harvard University, expects to leave Cambridge on February 7, for a two-months' trip through the middle west to the southwest and south, during which he will make a large number of addresses to Harvard alumni and others.

DR. ALBRECHT PENCK, professor of geography at Berlin, and this year Kaiser Wilhelm professor at Columbia University, has been given the degree of doctor of science by Columbia University.

THE Wahlburg gold medal of the Swedish Society for Anthropology and Geography will be presented to Dr. Sven Hedin on his return to Stockholm. This is the second

presentation of the medal, it having been given previously to Professor G. Retzius.

Professor Theodore W. Richards has received a seventh grant of $2,500, and Assistant Professor Gregory P. Baxter a fifth grant of $1,000, from the Carnegie Institution of Washington, to aid in researches upon physico-chemical constants.

Mr. E. R. Lloyd, Rhodes scholar at Oxford from West Virginia, who was placed in the first class in the final honor schools, has been awarded the Burdett-Coutts scholarship in geology, which is held for two years and is of the annual value of £115.

King Edward has appointed Dr. H. R. D. Spitta to be bacteriologist to his household.

Mr. Raphael Zon, who will have charge of the forest experiment station work in the reorganized Forest Service, is now abroad studying the stations in Europe.

Mr. C. A. McLendon has resigned the position of assistant botanist and plant pathologist at the South Carolina Experiment Station to accept the position of botanist and plant pathologist at the Georgia Experiment Station, Experiment. He takes the place recently vacated by the removal to the State College, at Athens, of Professor R. J. H. De Loach.

It is announced that Professor George Hempl, of Stanford University, has made important discoveries in the interpretation of inscriptions left by the Etruscans.

Professor S. A. Mitchell, of Columbia University, on successive Saturday evenings, beginning January 9, delivers a course of lectures on "Astronomy" at the Wagner Institute, Philadelphia, as follows: (1) The sun and its motion through space; (2) Eclipses of the sun; (3) Wonders of the heavens revealed by the spectroscope; (4) Foucault's pendulum; (5) The moon; (6) Is Mars inhabited?

The Southern California Science Association was organized at Occidental College, Los Angeles, Cal., on December 12. The next meeting will be held in April at the University of Southern California, Los Angeles. The following officers were elected at the meeting for organization: *President,* W. A. Fiske, Occidental College, Los Angeles; *Vice-president,* W. R. Bowker, University of Southern California, Los Angeles; *Secretary-treasurer,* H. T. Clifton, Throop Polytechnic Institute, Pasadena.

At the meeting of the Middletown Scientific Association, on January 12, Charles Edward Amory Winslow, assistant professor of sanitary biology at the Massachusetts Institute of Technology, gave an illustrated lecture on "Water Supply and Water Purification."

Dr. John A. Brashear lectured at Lehigh University on December 11 on contributions of photography to our knowledge of the stellar universe.

The agricultural faculty and experiment station staff of Clemson College, S. C., have formed an organization to be known as the Clemson Biological Club. Dr. C. H. Shattuck has been elected president and Professor A. F. Conradi, secretary. Regular meetings will be held each week.

The British Admiralty will restore Halley's grave in the old burial-ground of Lee Parish Church. E. Halley, who was the astronomer royal from 1721 to 1742, was given the temporary rank of a captain in the navy, and commanded a ship of war in 1698–1701, for the purpose of making observations for magnetic variations.

A committee has been formed in Denmark to erect a memorial to Mylius Erichsen, who perished with his companions while engaged in explorations in Greenland. It is expected that the memorial will take the form of a lighthouse to be erected on the Danish coast.

A monument to Professor von Krafft-Ebing, was unveiled in the hall of the University of Vienna at the time of the recent international congress in that city on the care of the insane.

It is proposed to erect a building for surgical cases in connection with the Presbyterian Hospital, New York, as a memorial to the late Dr. Andrew J. McCosh. The chairman of the committee having charge of the memorial is Mr. John S. Kennedy, New York City.

The Brooklyn Institute of Arts and Sciences held a Charles Darwin centennial meet-

ing on the evening of January 12, when an address on "Charles Darwin and his Influence" was made by Professor Edward G. Poulton, of Oxford University.

As we have already announced, arrangements have been made for the celebration of the one-hundredth anniversary of the birth of Charles Darwin by the New York Academy of Sciences on February 12 at the American Museum of Natural History. In addition to the presentation to the museum of a bust of Darwin—the presentation to be made by Charles F. Cox, president of the academy, and the acceptance by Henry F. Osborn, president of the museum—addresses will be made on "Darwin's work in botany," by Professor N. L. Britton; on "Darwin's work in zoology," by Professor H. C. Bumpus; and on "Darwin's work in geology," by Professor J. J. Stevenson.

DR. GEORGE GORE, F.R.S., formerly lecturer on chemical and physical science at King Edward's School, Birmingham, the author of works on electrometallurgy and other subjects, has died at the age of eighty-two years.

A RECENT communication from Vienna announces the death, after a long and painful illness, of the eminent Austrian physicist and meteorologist, Hofrat Professor Dr. Josef Maria Pernter on December 20, 1908, at Arco, Tyrol, Austria. Professor Pernter was the director of the Austrian Central Institution for Meteorology and Geodynamics, Hohe Warte, Vienna, a member of the International Meteorological Committee and vice-president of the Austrian Meteorological Society. His death at the comparatively early age of sixty may leave still incomplete his important "Treatise on Meteorological Optics."

WE learn from the *Journal* of the American Medical Association that the recent small epidemic of yellow fever at Saint-Nazaire, on the French coast, has impressed on the authorities the necessity for more effectual measures against yellow fever in the French colonies, whence the disease was imported. The task was entrusted to Drs. Simond and Marchoux, who spent some time in Brazil two or three years ago in study of tropical diseases. They left for Martinique November 11, fully equipped for the extermination of yellow fever and malaria mosquitoes in Martinique and Guadeloupe.

THE appropriation bill in which are included the appropriations for carrying on the work of the Bureau of Education has passed the House of Representatives and is now in the Senate Committee on Appropriations. The only increase over appropriations for the previous year made by the House of Representatives is provision for an editor at two thousand dollars per annum. The bureau needs badly provision for larger and more sanitary quarters than it now occupies, a considerable increase in its staff, as well as an increase in the salaries of the present members of the staff, and is endeavoring to secure these increases in the Senate.

A BULLETIN from the Harvard College Observatory, under date of January 5, states that the variable star, 154428, R Coronæ was found by Mr. Leon Campbell to be faint on January 1, 1909, magn. 8.2. This star is usually of the magnitude 6.0, but occasionally undergoes marked and apparently irregular diminutions in light, sometimes becoming as faint as magnitude 13. The last diminution in brightness lasted from February 8 to September 6, 1905. On November 12, 1908, its magnitude was 6.1, and on December 13, 1908, it was 6.9. Only two other stars of this class have been as yet discovered, *191033*, R J Sagittarii and 054319—Tauri, the latter being now exceedingly faint. All three of these stars are being followed closely, both photographically and visually.

THE *American Museum Journal* states that through Edward L. Dufourcq, the directors of the Minas Pedrazzini Company at Arizpe, Sonora, Mexico, have presented to the mineral cabinet a remarkable specimen of crystallized polybasite. This ore of silver (sulphantimonide of silver with some of the silver replaced by copper) furnishes a large part of the vein material from which the silver is obtained in this mine. At favorable points there have developed beautifully crystallized specimens of the mineral upon a scale of magnitude almost

unique. The entire mass as forwarded consisted of a crystallized surface, displaying small and large crystals, nestling upon an ore body of considerable size. The value in bullion of this aggregate was $640, and it probably was the largest mass of polybasite ever taken from a mine entire.

The growth of the mineral industries of the United States is graphically exhibited by a chart just issued by the Geological Survey, tabulating for each year of the last decade the quantity and value of the output of our metallic and non-metallic mineral products. This chart shows that in 1898 the domestic production of the metals—pig iron, silver, gold, copper, lead, zinc, quicksilver, aluminum, antimony, nickel and platinum—had a total value of $305,482,183; in the same year the total value of the other mineral products amounted to $418,790,671; the grand total for the country in 1898 was therefore $724,272,854. Ten years later, at the close of the calendar year 1907, the value of the metals had increased to $903,024,005, that of the other products to $1,166,265,191, and the grand total was $2,069,289,196. The chart has interest in connection with a summary of the mineral production of the country, published by the survey as an advance chapter from "Mineral Resources of the United States, Calendar Year 1907," and copies of both the chart and the summary may be obtained by applying to the director of the survey at Washington, D. C. The survey has also published for free distribution separate chapters of its annual report on the mineral resources of the country, giving detailed statistics of many of the products that make up these totals.

Nature states that the council of the Röntgen Society has decided to act upon the advice of the committee appointed in 1906 to consider the possibility of preparing a standard for the measurement of radioactivity. This committee recommends that "The γ-ray ionization from 1 mg. of pure radium be regarded as a standard, and called a unit of radioactivity." The council has deputed Mr. C. E. S. Phillips to prepare a set of three substandards of $RaBr_2$, and these are now maturing. By the cooperation of Professor E. Rutherford, comparison will be made with a specimen of the purest $RaBr_2$ at the Victoria University, Manchester. The quantity of radium in other specimens will be capable of accurate measurement by comparison with the substandards. It is anticipated, therefore, that by this means the exact description of medical, physical or other work with radium will be facilitated, and that the possibility of fraud in the sale of expensive radium preparations will be eliminated. The council proposes to lend the substandards to any competent person desiring to measure the amount of radium in his possession, or to arrange for authoritative tests to be made. For further particulars application should be sent to the honorary secretary of the Röntgen Society, at 20 Hanover Square, London, W.

The following, as we learn from the *British Medical Journal*, are among the prizes awarded by the Paris Académie de Médecine for 1908: The Laborde prize (£200) for the most notable advancement of surgery, has been given to Professor Monprofit, of Angers, for his work on the operative surgery of the stomach; the Theodore Herpin prize (£120) has been gained by Dr. Albert Deschamps, of Riom, for an essay on the diseases of energy—general asthenias; the Amussat prize (£40) has been awarded to Dr. Destot, of Lyons, for a radiographic and clinical study.

UNIVERSITY AND EDUCATIONAL NEWS

Iowa College has obtained an additional endowment of $500,000, of which $100,000 is from the general education board and $50,000 from Mr. Andrew Carnegie.

Mr. John W. Gates has given $100,000 to establish a college at Port Arthur, Texas.

Mr. Jacob H. Schiff, of New York City, has given $100,000 towards the construction of a Jewish institute of technology at Haife, Palestine.

We learn from the London *Times* that the foundations of the laboratory which is being given to the University of Oxford for electrical work by the Drapers' Company are now being constructed. The laboratory will measure

about 104 feet by 92 feet by 51 feet high, and will be built of red brick and stone. It will be situated in the Parks close to the other buildings devoted to science, which are grouped around the museum. The ground floor will contain a class-room 50 feet by 27 feet, a workshop of about the same dimensions, as well as research, battery and dark rooms. On the first floor provision is made for a lecture-hall 36 feet square and two class-rooms over 50 feet long, while on the second floor there will be a class-room about 100 feet long, besides large lecture and research rooms.

THE President of the United States has instructed the Commissioner of Education to aid in all appropriate ways within his power in the carrying out of the plans of the Chinese Government for the education of students in America. The Chinese Government purposes sending 100 students to America every year for four years, and a minimum of 50 students every year thereafter during the period of the cancelled indemnity payments by China to the United States, from 1909 to 1940.

PROFESSOR DONALD J. COWLING, of Baker University, Baldwin, Kas., was elected president of Carleton College, Northfield, Minn., to succeed the Rev. R. H. Sallmon.

MR. W. H. EMMONS, of the U. S. Geological Survey, is giving courses on petrography and economic geology at the University of Chicago.

DR. A. J. GROUT has been appointed first assistant in biology in the Curtis High School, New Brighton, Staten Island.

DR. ARNOLD LANG, of Zurich, has declined the call to Jena as the successor of Professor Haeckel.

PROFESSOR PFLÜGER, of Breslau, has been called to Berlin as director of the Institute of Hygiene in the place of Professor Rubner who has been transferred to the chair of physiology.

DISCUSSION AND CORRESPONDENCE

A DISCLAIMER

HARDLY had the experimental researches at the Nutrition Laboratory of the Carnegie Institution of Washington, located in Boston, been established when the scientific staff were besieged by innumerable newspaper reporters seeking information whereon they could base sensational articles for distribution in the public press. Much to my regret, a lengthy article was distributed broadcast throughout the American press on December 20, purporting to describe the Nutrition Laboratory, the experiments made therein, and the plans for the future. It is needless to say that the whole article was prepared without my knowledge and has left an entirely erroneous impression with regard to the work of this institution.

Briefly, the researches now being carried out in Boston were instituted by Professor Atwater, at Wesleyan University, some fifteen years ago. After Professor Atwater's untimely retirement, I had charge of the researches at Wesleyan University and since then they have been transferred to Boston to a special laboratory. The apparatus used at Wesleyan University has been described in detail in Publication No. 42 of the Carnegie Institution of Washington and a discussion of a series of experiments with it made on man during inanition was reported in Publication No. 77 of the institution. The forthcoming "Year-book of the Carnegie Institution" contains a short statement of the laboratory, the plan, and general information regarding it. The newer calorimeters have not been described as yet. All results of experiments made in this laboratory will be published in regularly accredited scientific journals and in the reports published by the Carnegie Institution of Washington. It has been my policy not to publish original scientific material in popular scientific or semi-scientific magazines, much less would I use the daily newspaper as a vehicle for presenting this material to the scientific public.

In connection with the last newspaper announcement regarding this laboratory, there is a very unfortunate statement that as a result of experiments thus far made in the laboratory, the treatment of diabetes would be materially modified and improved, thus holding out hope to the large number afflicted with this

disease that a speedy recovery might be expected. Indeed, I have already begun to receive letters from these unfortunate diabetics who have thus had their hopes falsely raised.

Francis G. Benedict
Nutrition Laboratory,
Carnegie Institution of Washington,
Boston, Mass.

The Late Professor Packard's "Guide to the Study of Insects"

My father, Professor Alpheus Spring Packard, had purposed to rewrite and bring the "Guide to the Study of Insects" up to date, as soon as he had finished Part II. of his "Monograph of Bombycine Moths," which was going through the press at the time of his death. He left many notes and references in regard to the "Guide," which we had intended to use as a preface, but we find they can not be edited properly by another hand.

Alpheus Appleton Packard
New London, Conn.,
January 2, 1909

Quotations

The Administration at the University of Illinois

The University of Illinois has been coming to the front in the last few years more rapidly than any of the other state universities. It now ranks eighth among the great universities of the United States in the number of students, and is receiving large appropriations from the legislature, for the people of Illinois are determined that their own institution shall not be surpassed by any within the state, especially one founded by John D. Rockefeller. More important than its growth is the raising of the standard of scholarship, the introduction of new men of ability and promise, and the opening of a graduate school. This rapid progress is to be credited chiefly to the energy and initiative of President Edmund J. James, who left Northwestern four years ago to take charge of the state university.

But the University of Illinois is suffering somewhat from the twinges of growing pains. Such a radical and rapid transformation can not be effected without hurting the feelings of some one or several. One such, Dr. George T. Kemp, has made his grievance a public question by his articles in the local papers and in Science of October 9, charging President James with duplicity, dishonesty and abuse of official powers. Dr. Kemp does not ask for sympathy on personal grounds. If his manner of leaving the university has impaired his chances of getting a position in another college, he can fall back on his profession, and make more money by the practise of medicine. But he holds that the question of academic freedom *versus* presidential tyranny is involved in his case, and it is therefore of public importance.

The essential facts seem to be as follows: When the graduate school was established a year ago, certain departments were selected for development, as it was impossible to bring them all at once to this rank. Professor Kemp was not one of the professors promoted, his salary was not raised to the prevailing rate, and his department did not share in the general prosperity. He felt, doubtless rightly, that this indicated that he was not in favor with the administration, and, being a high-spirited man, he resented it as a slight upon his honor and ability. He forced the issue by demanding "a court-martial" before the board of trustees and the formulation of specific charges. This mode of procedure was not adopted, but Dr. Kemp appeared before the board two or three times, presenting witnesses and papers to prove his success as a teacher and investigator, and calling attention to alleged defects in the organization of the university. Then finding the opposition to him still undefined and undiminished, he resigned his position and has since been waging war from the outside against President James and "the system." The board of trustees, regarding his resignation as voluntary, refuses to reopen the case and holds that he had no just grievance against the administration.

Dr. Kemp bases his charge of duplicity and unfair treatment chiefly on the fact that after his last appearance before the board his case was discussed by the president, who at that time stated his opinion of Dr. Kemp and why he did not regard him as worthy of promotion.

We do not see that this charge is well founded. We do not see why the technicalities of legal procedure should be followed in such cases. Certainly our courts are not so prompt and efficient in their action as to commend their methods for extension into academic circles. It is the business of boards to talk over freely the qualifications and defects of the professors, and they would be seriously hampered in their consideration of the subject if the individuals discussed had to be present or represented by attorney.

The reason why no definite and serious charges such as would necessitate his dismissal were brought against Dr. Kemp was probably because there were none to bring. The president seems to have objected to him on the ground that he was not a first-class teacher or administrator and that he was a hard man to get along with. These are as intangible as they are important, and it is difficult to see how they could be proved or disproved by any form of court-martial. President James practically appealed to the trustees to express their confidence in his judgment of men, and this is what they have done. Since to be a good judge of men is one of the most important qualifications of a college president, they could hardly have decided against him if they thought him worthy of office. It may be that President James underestimated Dr. Kemp's ability and overestimated his incompatibility, but the error, if it were such, does not involve any moral obliquity. The University of Illinois should have the best physiologist it can find, and it is not clearly demonstrated that Dr. Kemp is that man.

We believe that the board of trustees are right in holding that further discussion of the case is unnecessary and detrimental, although we do not regard their resolutions, reported in *The University of Illinois Press Bulletin* of December 16, as satisfactorily worded. We do not find in Dr. Kemp's letter of resignation the reasons they quote as his. The letter as published in SCIENCE gave altogether different reasons. And the statement made by the board that Dr. Kemp's resignation was not even suggested at the board meeting is quite too sweeping an assertion.

On the whole, we fail to find evidence to prove that academic freedom is in danger in the University of Illinois or that President James is more autocratic than other successful presidents, as, for example, our revered President Eliot. He certainly is less inclined to be arbitrary and dictatorial than his predecessor, President Draper. We can not here enter upon the wider question of whether a more democratic system of government, such as is advocated by Professor Cattell, is desirable. At present the tendency is to regard a stronger centralized and personal administration as best for universities and cities. The liability to abuse such power is checked by the watchfulness of supervising boards and by the fact that an aggrieved party may appeal to Cæsar, *i. e.*, SCIENCE.—*The Independent.*

SCIENTIFIC BOOKS

Essays on Evolution, 1889–1907. By E. B. POULTON, Hope Professor of Zoology in the University of Oxford. Oxford, Clarendon Press. 1908.

Professor Poulton is well known as an ardent neo-Darwinian and as one who has made the subject of insect mimicry his own, the wonderful collection illustrating this interesting phenomenon in the Hope department of the Oxford Museum being a monument to his enthusiasm, energy and information in this field of investigation. In the volume of essays now under review these two topics are very much in evidence, the essays being for the most part addresses delivered by the author on various occasions, now brought up to date and reprinted. Inasmuch as the essays dealing with the Darwinian theory were originally written before the theory of mutations and Mendelism had become important factors in the question of the origin of species, Professor Poulton has added an introduction to his book dealing with these topics and protesting against the extreme position taken by those whom Professor Hubrecht, himself an upholder of the mutation theory, has lately characterized as "silly antagonists of Darwinism and evolution, who have thought fit to proclaim with a loudness that is in inverse ratio

to the square of their accuracy that Darwinism has been played out since the appearance of de Vries's 'Mutations-theorie.'" It can not be said that Professor Poulton doth protest too much, but he certainly errs in the same direction as those against whom his protest is directed, in that he endeavors, unnecessarily for his purpose, to minimize the importance of both mutations and Mendelism, instead of recognizing them as factors in bringing about conditions upon which natural selection may act.

The first essay is a discussion of the age of the earth, considered from the standpoint of an evolutionist, and had for its exciting cause Lord Salisbury's presidential address to the British Association at the Oxford meeting in 1894. The question is an old one and has had many answers, none of which are very definite, nor does Professor Poulton's discussion of it lead to any more definite conclusion than that the earth must be old enough to have allowed time for the accomplishment of evolution. This will, no doubt, be quite acceptable to evolutionists. Similarly, the second essay, on "What is a Species?" while interesting as a discussion of the meaning that has been applied to the word species at different times, naturally leaves one with a sensation of indefiniteness, and the three succeeding essays, on "Theories of Evolution," "Theories of Heredity" and "The Bearing of the Study of Insects upon the Question 'Are Acquired Characters Hereditary?'" discussions of the respective merits of the old antagonists, Lamarckism and Weismannism, while more interesting reading than the majority of such discussions, yet, again, are quite as futile as these so far as any settlement of the questions at issue are concerned.

The sixth and seventh essays are largely historical. The sixth deals with the views concerning inheritance advanced by the anthropologist, Prichard, in his "Researches into the Physical History of Mankind" (2d edition, 1826). These constitute a remarkable anticipation of the conclusions later advanced by Weismann concerning the non-transmissability of acquired characters, as a quotation of one sentence from the work will suffice to show. Prichard says "changes produced by external causes in the appearance or constitution of the individual are temporary, and, in general, acquired characters are transient; they terminate with the individual, and have no influence on the progeny."

In the seventh essay Huxley's position on the question of natural selection is considered, and it is maintained that he "was at no time a convinced believer in the theory." This conclusion can not but seem strange when one recalls that Huxley received from Darwin the title of "general agent" by the vigor with which he wrote and spoke on behalf of the new theory. Professor Poulton certainly makes out a strong case, claiming that Huxley, while a strong evolutionist, was unable to appreciate the bearings of the theory of natural selection, his inclinations being towards the study of the "engineering side of nature," rather than towards the contemplation of structure in relation to environment. But in opposition to Professor Poulton's conclusion one may oppose Huxley's own statements. Writing to Darwin in 1859 he says:

> As to the first four chapters [of the Origin], I agree thoroughly and fully with all the principles laid down in them. I think you have demonstrated a true cause for the production of species, and have thrown the *onus probandi*, that species did not arise in the way you suppose, on your adversaries.

True, he goes on to confess that he did not feel that he had fully realized the bearings of the theory of natural selection, and criticizes the adoption of the principle that *natura non facit saltum* and the slight importance assigned to continued physical conditions as a cause of variations. These criticisms do not, however, apply to the theory of natural selection; they concern only the question of the origin of variations. Further, writing in 1880, he said:

> I hope you do not imagine because I had nothing to say about "natural selection [in "The Coming of Age of the Origin of Species"], that I am at all weak of faith on that article. On the contrary, I live in hope that as paleontologists work more and more . . . we shall arrive at a

crushing accumulation of evidence in that direction also.

These statements can hardly be regarded as those of an unbeliever, but suggest the possibility that Professor Poulton is speaking in his essay as a neo-Darwinian, an upholder of the doctrine of the all-sufficiency of natural selection.

The latter part of the Huxley article and the remaining three essays are devoted to a consideration of the question of insect mimicry. They are the *pièces de résistence* of the whole volume, forming, as they do, the most thorough exposition of the significance of insect coloration we possess or are likely to possess until the fuller treatise promised by the author is published. In the abundance of illustrations cited and in the keen criticism to which the various cases are subjected the essays stand alone, and their usefulness is immensely increased by the addition of a list of the mimicking and mimicked forms referred to, and also by the most complete and thorough index to the entire volume that it has ever been the present reviewer's pleasure to use. If any points may be selected for special mention from a treatise whose general excellence is so high, they are the evidence advanced tending to place the Mullerian theory of common warning coloration on a firmer basis, and the extension of its applicability to a greater number of cases at the expense of the Batesian theory of mimicry.

What has been said above is intended as a review of the book from the standpoint of a biologist. To non-biological readers the perusal of every essay will be both pleasurable and profitable; pleasurable because Professor Poulton's style is admirable and both his description of facts and his statement of criticisms clear, and profitable because his information concerning the topics of which he treats is extensive. Accuracy is never sacrificed to an attempt to popularize the subject; such a defect is unnecessary in the writings of one who has so marked a faculty for the exposition of scientific topics in a manner intelligible to the general reading public.

J. P. McM.

THE GENERA OF AFRICAN PLANTS

THE agricultural, commercial and industrial activity of Europeans in Africa has been so great of recent years that the interior of that great continent has become to-day perhaps the most eagerly exploited field in descriptive botany, not even excepting the Philippines under American administration.

Though the British and French pretty evenly divide honors in the earlier study of African botany, and the former are likely long to maintain their lead in knowledge of the Cape flora, other nations have contributed very materially to our knowledge of the dark continent; and despite the fact that England was the first to press into the tropical interior, the present development of the latter has fallen largely to the Germans and Belgians.

To botanists possessed of collections of African plants, no recent publication is likely to be more directly and frequently helpful than Thonner's "Blütenpflanzen Afrikas."[1] This stately volume brings together in synoptical form the scattered skeletal elements of the flora as a whole. Nomenclature, taxonomy and general ideas of segregation follow the Berlin practise. Well-contrasted keys are provided for the differentiation of families, and, under them, of genera: and the illustrations, from original drawings, simplify the application of text-characters. Indexes to popular and Latin names of plants add to the value of the book.

One of the most interesting features of the manual is a tabulated conspectus of the known African plants, which may be summarized as follows:

Distribution.	Families	Genera	Species
Total known	285	9,942	136,000
African	221	3,648	39,000
Indigenous	213	3,486	38,600
North African		981	4,850
Middle African ...		2,185	18,300
South African		1,393	13,300
Insular		1,266	5,950

[1] Thonner, F., "Die Blütenpflanzen Afrikas: Eine Anleitung zum Bestimmen der Gattungen der afrikanischen Siphonogamen," Berlin, Friedländer, 1908, pp. xvi + 673, pl. 150, 1 map.

Though the families not represented in Africa are mostly of local distribution elsewhere and usually little differentiated into genera or even species, a comparatively few, like Magnoliaceæ, Styracaceæ and Polemoniaceæ, are elsewhere widely distributed and extensively differentiated. To one accustomed to the weeds of highly agricultural countries outside the tropics, with extensive interchange of the wares of commerce, the introduced plants of Africa appear peculiar, Araceæ, Zingiberaceæ and Myrtaceæ being prominent among them while our own customary weed groups like Gramineæ, Labiatæ, Caryophyllaceæ, Chenopodiaceæ, Amaranthaceæ and Umbelliferæ are either unrepresented or little prominent.

If a much larger number of thumb-nail details of genera had been substituted for full-plate illustrations of species, and if references had been given to monographs by aid of which the African species of a genus might be determined, the book would have been more useful: but even without these it is going to prove very helpful to those who study African plants in the field, herbarium or garden.

W. T.

Neurological and Mental Diagnosis. A Manual of Methods. By L. Pierce Clark, M.D., and A. Ross Diefendorf, M.D. New York, The Macmillan Company. 1908.

The title of this work is a misnomer. The book might be called a primer of nomenclature of nervous and mental symptoms, with description of the simpler methods of examination technique, but exclusive of all the methods of actual neurological and psychiatric diagnostic reasoning. This holds especially for the neurological part, which gives only a very elementary description of routine of examination which could hardly be called sufficient to lead to a diagnosis in a fairly large number of cases with vital issues involved.

The second part is an epitome of terms and definitions in psychiatry and ways of getting hold of the corresponding facts, with the addition of a standard case for each of the three standard types of dementia præcox, for dementia paralytica or paresis, melancholia, "the" two forms of manic-depressive insanity, paranoia, alcoholic hallucinosis and amentia, arranged in the set formula assumed for the average examination. This is followed by twenty-eight pages of a "glossary of terms commonly used in psychiatry," adding materially to the scholastic tenor given the whole presentation. Very satisfactory photographs of the patients accompany most of the histories. The photographs and drawings of the neurological part give the positions in testing for reflexes, and the points of electric stimulation and the sensory segments.

There is no doubt about the desirability of outlines of examination, especially if they are sufficiently perspicuous in the arrangement of topics and the various steps to be followed to serve *during examinations,* and if they are small enough to be carried in the pocket, or still better, if they serve as a sort of portfolio, as a support in writing, as well as a protection against oversights. Neither of these purposes is served by the book, nor can it be called more than a partial summary of the ordinary methods and their technique, with the chief point, namely, the safeguards about interpretation, left practically untouched.

As a sample specimen of the neurological work a composite case record—under the best of circumstances likely to be a libel against nature—is furnished with the heading:

Oct. 1, 1907. William Johnson, 36, s., Eng., in U. S. 10 years.

Diagnosis: Tabes Dorsalis.

In the course of the not especially clearly arranged notes, without any evidence of change of heading or diagnosis or suggestion as to what was aimed at, we find the man married at 22, with 3 children; then—"one year ago (Oct., 1904)" a symptom-complex suggesting cerebral syphilis is credited to him, and in the direct examination the patient is a "blond German," but still 36 years old. The chief danger of records, the prevalence of form over sense, is unnecessarily and unintentionally exemplified.

In the review of the methods in a mental diagnosis the essential facts of the neurological diagnosis are done over. The general

plan of psychological examination may have the advantage of didactic simplicity, but it will lead rather to the picking out of a verbal diagnosis than to an understanding of the meaning and spirit of the disorder of the patient.

The mental cases given are clear but very elementary and there is very little help towards finding the way, where actual difficulties would arise.

In a future edition the grouping and the interpretation and utilization of the results should be given better attention, and by using different types of print the important and obligatory steps might be put into contrast with the matters to be used to settle less common difficulties.

A. M.

SCIENTIFIC JOURNALS AND ARTICLES

The Bulletin of the Charleston Museum for November comprises Notes on Taxidermy, Library News, Notes from the Museum and notices of The Natural History Society. The sound advice is given to those interested in taxidermy to practise on English sparrows and not endeavor to mount a bird until they can put up a good skin. The library possesses some interesting portraits of former officers and a bust of Bachman.

The Museum Journal of Great Britain for November contains accounts of the "Oxford Museum Jubilee" and the "Museum Conference in Rochdale" and "The Arrangement of an Egyptological Collection," by W. E. Hoyle. This comprises a suggested classification of exhibits and three alternative schemes for arrangement, chronological, topical and ideal, the latter being an effort to present a general view of Egyptian civilization. Arthur Fairbank presents the plans for "The New Building for the Museum of Fine Arts in Boston."

The Zoological Bulletin, Division of Zoology, Pennsylvania Department of Agriculture, though dated September 1, has only recently been received. It is devoted to a "First Report on the Economic Features of Turtles of Pennsylvania" and is a companion volume to the serpents of Pennsylvania previously issued. The report comprises descriptions of all the turtles found in Pennsylvania, with accounts of their habits, value as food, and their beneficial or harmful character as indicated by the plants and animals on which they feed. The large amount of information as to habits and the food of turtles makes the paper particularly valuable. Half-tone plates, mostly provided from the American Museum of Natural History, are given of the various species and there are also in the text many most excellent pen drawings by W. R. Walton. Two original plates show good series of the variable and closely related species *Chrysemys marginata* and *C. picta.* Mr. Surface is to be congratulated on having placed so much information within reach of so many readers.

SPECIAL ARTICLES

THE TEXAS TERTIARIES—A CORRECTION

THE original section of the Texas Tertiary published in the *Journal of Geology* for 1894 made the Eocene end with the Frio substage of the Claiborne, which was followed immediately by the Oakville beds of supposedly Miocene age. Based on this classification and on the decision of Professor G. D. Harris that fossils found in sandstones just north of Corrigan were of Claiborne age, Mr. Kennedy referred these sandstones to the Fayette sand and the overlying or Fleming clays to the Frio. Larger collections from this locality made later by Mr. Veatch proved the Jackson age of the sandstones and this implied a similar wrong assignment on our part of the Frio clays. From Mr. Veatch's statement in his report "Underground Water Resources of Northern Louisiana and Southern Arkansas," he evidently considered the reference of the Corrigan beds as made by Kennedy incorrect, and our recent stratigraphic work on them has proved this to be true.

On the Rio Grande, Nueces and San Antonio rivers, and probably on the Colorado, the original section holds, and the Frio beds which carry Eocene fossils in places are immediately overlain by the Oakville. In the eastern part of the state, however, beds of Jackson age appear in places between the Frio and Oakville.

On the Houston East and West Texas Railway, the sands which really represent the Fayette beds occur around Lufkin, but the exposures on the railroad, where the section was originally made, are so small that they were considered as simply a part of the Yegua beds, which were thereby given a much greater areal distribution than elsewhere and made to include the overlying Frio clay as well.

The contact between the Yegua and Fayette should have been given as just north of Lufkin and the Frio clays should have been shown as occupying the area between Burke and the top of the bluff on the south bank of the Neches River. At this latter point, we have the contact of the sandy limestone containing Jackson fossils, and this is overlain by the Fleming-Burkeville beds, while the Oakville sands appear just south of Corrigan. Similar conditions exist east and northeast of Corrigan to the Sabine River, and it is altogether probable that some of the deposits lying to the west and classed by Kennedy as Navasota beds may belong to this same horizon.

The same section is also shown on the Conchas River in Tamaulipas, Mex., where the Fayette sand, with its characteristic fossil *Ostrea alabamiensis* var. *contracta* is overlain by the Frio clays and these in turn by sandstones with a distinct Oligocene fauna.

It would therefore appear that while the Oligocene was probably laid down entirely across this area, it is now covered in many places by the overlapping Oakville.

E. T. Dumble

THE SIXTIETH MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, BALTIMORE, MD., DECEMBER 28–JANUARY 1, 1908–9

One of the most successful meetings in the history of the American Association, and in some regards the most successful, was brought to a close Friday evening, January 1, 1909, at Baltimore. Ample provisions for a large meeting were made by the local committee, and the expectations were fully realized. The total registration of the members of the association was 1,088 and the affiliated societies reporting adds 117. The next largest registration to this was at Washington, in 1903, when 903 were recorded. But, as always, many in attendance were not registered, and a conservative estimate would bring the attendance of scientific men up to about 2,000. One striking feature in the attendance was the large number of men from the various government services in Washington, who came over and lent their presence in the meetings of every section.

Great credit is due to the energy and efficiency of the local committee, of which Professor Wm. H. Welch was chairman and Professor Wm. J. A. Bliss secretary. The meeting places, mostly in the buildings of the Johns Hopkins University and Medical School, were ample and convenient, and the hotel accommodations excellent. There was not a hitch in the carrying out of the program; every want was provided for in advance.

The opening session was held in the audience room of McCoy Hall, Johns Hopkins University, at 10 A.M. Monday, December 28, 1908, with the retiring president, Professor E. L. Nichols, of Cornell University, in the chair, who introduced the incoming president, Professor T. C. Chamberlin, of the University of Chicago, who presided. Addresses of welcome were made on behalf of the educational institutions of the city by President Ira Remsen, on behalf of the local committee by Dr. Wm. H. Welch and on behalf of the city of Baltimore by the mayor, Hon. J. Barry Mahool. It was recalled that when the association met in Baltimore fifty years ago, the membership was only 1,000 and the attendance at the meetings only 200, while now the membership has grown to 7,000 and the association has been divided into eleven sections, each devoted to a phase of scientific work, and even sections subdivided, in the case of Section C, chemistry, there being eight subsections, each with large attendance, and papers enough to occupy two or three days in the reading.

The presidential address by Professor E. L. Nichols, of Cornell University, was given in the hall of the Peabody Institute before a large audience of members and citizens of the town. The address was a masterly presentation of the thought that all the material advance of society is based on the discovery of laws and the establishment of principles by research in pure science; that the most of this research and of these contributions up to date have been made in lands across the sea; that our universities are not properly providing for research, and that great improvement along these lines is possible, the recent noble bequest of Senator Vilas to the University of Wisconsin for the endowment of research professorships pointing the way.

After the presidential address a reception to the members of the association and affiliated societies was tendered by President Ira Remsen at McCoy Hall. The reception was largely attended and was a very pleasant affair.

Sectional meetings began on Monday afternoon, and were continued till Friday evening, when all papers were read or otherwise disposed of. Certain of these sectional meetings were favored with record attendance, and with programs of exceptional interest and value. Section B reports the most successful meeting of its history. The joint meeting with the American Physical Society gave a record attendance. It was probably the largest gathering of physicists that has ever occurred in America. Eight sessions were held, and 54 papers presented. The dinner held at the Country Club on Tuesday evening had a attendance of 91 and was voted the pleasantest event in the history of the section.

Section E, in affiliation with the Geological Society of America, held a memorable symposium on "Correlation in Historical Geology." Sixteen papers were presented in this symposium, running through six sessions. A feature was a remarkable series of maps by Mr. Bailey Willis, showing the paleogeography of the continent of North America in many stages of its formation up to the present, showing what was certainly land, and certainly sea, areas sometimes land and sometimes sea, and the areas of uncertainty. Quite significant was the presentation of the logic of correlation by Professor T. C. Chamberlin, the first term in every series of phenomena to be interpreted being shown to be found in diastrophic changes.

The most important event in the week for Section F was the vice-presidential address by Professor E. B. Wilson, on "The Determination and Inheritance of Sex."

Section L reported a very successful series of meetings, thus proving the wisdom of its establishment last year. This section has adopted the plan of devoting each session to the discussion of a single topic. On Wednesday afternoon American College Education was the theme, discussed by Professors Josiah Royce, James H. Tufts and others. In his address as retiring vice-president Commissioner Elmer E. Brown pointed out effectively the chaos that exists in American educational standards, and defined clearly some of the problems that must be solved to bring order out of this chaos. A session was devoted to the discussion of the needs and possibilities of the U. S. Bureau of Education.

The affiliated societies meeting with the association this year were the American Society of Naturalists, the American Society of Biological Chemists, the American Anthropological Association, the American Folk Lore Society, the American Philosophical Association, the American Physical Society, the American Psychological Association, the American Physiological Society, the American Society of Vertebrate Paleontologists, the American Chemical Society, the American Society of Zoologists, the American Nature-study Society, the American Mathematical Society, the American Federation of Teachers of the Mathematical and the Natural Sciences, the American Institute of Electrical Engineers, the American Alpine Club, the Association of American Geographers, the Association of American Entomologists, the Botanical Society of America, the Entomological Society of America, the Geological Society of America, the Society of American Bacteriologists, the Association of American Anatomists, the Southern Society for Philosophy and Psychology, the Sullivant Moss Society and the Wild Flower Preservation Society.

Some actions of the council of the association are of general interest: A resolution was adopted authorizing the permanent secretary to send a letter of greeting to Dr. Martin H. Boyé, of Cooperstown, Pa., the sole surviving founder of the association. It was resolved that the publishers of SCIENCE and *The Popular Science Monthly* be authorized to send *The Popular Science Monthly* in place of *Science* to any members of the association who may specially request it.

An amendment to the constitution was introduced as follows: Amend Article 23, by the omission of the words "and secretary" after the word "vice-president," in the third line, and to insert after the words "preceding meeting," in the fourth line, the following words: "and the preceding secretary, and the presidents and secretaries of those affiliated societies which shall be designated by the council."

One of the pleasantest features of the week was the reception, largely attended, on Tuesday afternoon from 4 to 6:30, by the Maryland Historical Society at its rooms on Saratoga and St. Paul streets.

Quite significant and worthy of attention was the symposium on "Tariff Revision," by Section I on Tuesday afternoon; with papers by Messrs. Farquahar, Hamilton, Orton and Holt, and discussion by Dr. J. Franklin Crowell, of the *Wall Street Journal*, and Mr. Seymour C. Lewis. The recommendation of the last named gentleman, that the laboratory method be introduced into the tariff

management, by establishing a bureau in the Department of Commerce and Labor, composed of experts, who will make scientific studies and recommendations to Congress, so removing the question from partisan politics.

Another valuable meeting was the symposium on "Public Health" in McCoy Hall on Thursday afternoon, with addresses by Dr. Harvey W. Wiley, of the Bureau of Chemistry, Washington, on "The Nation's Pure Food Problem"; by Dr. L. O. Howard, on "The Economic Loss due to Insects that Carry Disease"; by Dr. Horace Fletcher, on "Vital Economics"; by Professor Irving Fisher, of Yale, on "Progress of the Movement for Health Reform"; and by Dr. Walter Wyman, of Washington, on "Public Health Administration." The very great preventable waste of human life, which is going on around us, was forcibly presented, and recommendations made for our government to take an intelligent and earnest interest in conservation of health as our greatest resource.

The crowning feature of the week was the Darwin Centenary Memorial. The entire day, Friday, was devoted to the celebration. The great audience room of McCoy Hall was filled to the doors during the presentation of the papers. The president of the association, Dr. T. C. Chamberlin, presided and opened the session with an address. Then followed Dr. Edward B. Poulton, of Oxford University, England, who spoke very entertainingly of "Fifty Years of Darwinism"; Professor John M. Coulter, of the University of Chicago, spoke on "The Theory of Natural Selection from the Standpoint of Botany"; and Professor E. B. Wilson, of Columbia University, discussed "The Cell in Relation to Heredity and Evolution." In the afternoon session Dr. Daniel T. MacDougal, of the Carnegie Institution, told of the "Direct Effect of Environment"; Dr. S. W. E. Castle, of Harvard University, explained "The Behavior of Unit Characters in Heredity"; Dr. Charles B. Davenport gave an account of "Mutation"; Dr. Carl H. Eigenmann, of Indiana University, discussed "Adaptation"; Professor Henry F. Osborn, of Columbia University, gave "Recent Paleontological Evidence of Evolution." This series of addresses will be issued as a memorial volume a little later in the year.

The close of the week's functions was the Darwin memorial dinner at Lehman's Hall. About 300 sat at table, and after the repast the president of the association, Dr. Chamberlin, presented Professor H. F. Osborn as the toast-master. Professor Osborn gave an interesting reminiscence of his youth, when working in Huxley's laboratory. Darwin visited the place, as the guest of Huxley, and the young Osborn, being the only American present, was introduced to Darwin. He spoke also of the spirit of Darwin and of Huxley which came to Johns Hopkins with Martin and with Brooks, both now gone. Professor Wm. H. Welch was then introduced and spoke of "The Debt of Medicine to Darwin"; Dr. Albrecht Penck, of the University of Berlin, spoke on "The Geographical Factor in Evolution," and Professor Edward B. Poulton, of Oxford, gave a lively and entertaining talk on "The Personality of Darwin." Then Professor Chamberlin closed the meeting with words of thanks and praise for those in Baltimore who so splendidly entertained the association.

At the final general meeting on Friday morning a resolution, introduced by Mr. Edward W. Morley, was passed, as follows:

Resolved, That the American Association for the Advancement of Science sincerely thanks the Johns Hopkins University and the other institutions of the city and also the citizens of Baltimore, for their generous hospitality during our meeting.

At the meeting of the general committee it was voted to hold the next meeting during convocation week, 1909–10, at Boston, and recommendations to following councils favoring successive annual meetings at Minneapolis, Washington, Cleveland and Toronto. It was voted that a summer session in 1910 at Honolulu would be desirable if suitable arrangements can be made.

Officers were elected as follows: President, Dr. David Starr Jordan, of Leland Stanford University; General Secretary, Professor Dayton C. Miller, Case Scientific School, Cleveland; Secretary of Council, Dr. F. G. Benedict, of the Carnegie Institution; Secretary of Section H, Professor George Grant McCurdy, of Yale University; Secretary of Section K, Dr. G. T. Kemp. Vice-presidents of the various sections were elected as follows: Section A, Professor E. W. Brown, of Yale University; Section B, Dr. L. A. Bauer, of the Carnegie Institution; Section C, Professor Wm. McPherson, of Ohio State University; Section D, Mr. J. F. Hayford, of the U. S. Coast and Geodetic Survey, Washington; Section E, Dr. R. W. Brock, director of the Canadian Geological Survey; Section F, Professor W. E. Ritter, University of California; Section G, Professor D. P. Penhallow, McGill University, Canada; Section H, Professor Wm. H. Holmes, chief of the Bureau of Ethnology, Washington; Section I, Dr. Carroll D. Wright, of Clark College; Section K, Professor C. S. Minot, Harvard University; Section L, Dr.

James E. Russell, Teachers College, Columbia University.

J. PAUL GOODE,
General Secretary

UNIVERSITY OF CHICAGO

THE AMERICAN MATHEMATICAL SOCIETY

THE fifteenth annual meeting of the society was held at Baltimore, Md., on Wednesday and Thursday, December 30–31, in affiliation with the American Association for the Advancement of Science. The total attendance at the four sessions was about seventy-five, including fifty-seven members of the society. Wednesday evening was set apart for a dinner, at which forty-five of the members were present.

The sessions opened at 10:30 A.M. and 2 P.M. on each day. President H. S. White occupied the chair, being relieved by Professor Morley and Vice-presidents Miller and Kasner. At the opening of the afternoon session on Wednesday President White delivered his retiring address on "Bezout's theory of resultants and its influence on geometry." The council announced the election of the following persons to membership in the society: Professor G. N. Armstrong, Ohio Wesleyan University; Professor P. F. Gaehr, Robert College, Constantinople; Dr. Frank Irwin, Princeton University; Miss Mary E. Wells, Mount Holyoke College. Six applications for membership were received. The total membership of the society is now 602, including 55 life members.

At the annual election, which closed on Thursday morning, the following officers and members of the council were chosen:

President—Professor Maxime Bôcher.

Vice-presidents—Professors Edward Kasner and E. B. Van Vleck.

Secretary—Professor F. N. Cole.

Treasurer—Professor J. H. Tanner.

Librarian—Professor D. E. Smith.

Committee of Publication—Professors F. N. Cole, D. E. Smith, Virgil Snyder.

Members of the Council to serve until December, 1911—Professors H. B. Fine, O. D. Kellogg, F. R. Moulton, E. J. Wilczynski.

The treasurer's report shows a balance of $6,995.80, including the life membership fund of $3,215.20. Disbursements, including the cost of publishing the *Bulletin* and *Transactions*, were $4,515.97. Sales of publications amounted to $1,385.36. The library now contains over 3,000 volumes. The Annual Register of the society, containing the list of members, constitution and by-laws, annual reports and catalogue of the library, is now in press and will be issued this month.

The following papers were read at the annual meeting:

R. D. Carmichael: "On r-fold symmetry of plane algebraic curves."

R. D. Carmichael: "A general principle of inversion, with applications."

W. R. Longley: "Some sufficient conditions in the theory of implicit functions."

C. L. E. Moore: "Properties of systems of lines in space of four dimensions and their interpretation in circle geometry."

F. R. Sharpe: "The topography of the integral curves of a differential equation."

Joseph Lipke: "Note on isotropic ruled surfaces."

John Eiesland: "On a species of cubic surfaces of the sixth class."

E. O. Lovett: "Integrable problems of three bodies."

J. I. Hutchinson: "On linear transformations which leave an Hermitian form invariant."

H. S. White (presidential address): "Bezout's theory of resultants and its influence on geometry."

Frank Morley: "Plane sections of the Weddle surface."

G. A. Miller: "Finite groups which may be defined by two operators satisfying two conditions."

F. L. Griffin: "Tests comparing the apsidal angles and periodic times for different laws of central force."

E. G. Bill: "Existence 'im Kleinen' of a space curve which minimizes a definite integral."

E. G. Bill: "An a priori existence theorem in three dimensions for the calculus of variations."

J. R. Conner: "Curves and surfaces which admit configurations of the Cayley-Veronese type."

D. D. Leib: "The complete system of invariants for two triangles."

W. A. Granville: "Dual formulas in spherical trigonometry."

C. J. Keyser: "Concerning euclidean geometries without points and lines."

M. E. Sinclair: "The problem of the surface of revolution with two end points variable on circles."

G. A. Bliss: "On the construction of the coordinate system of analytic projective geometry."

C. N. Haskins: "Numerical computation of reaction velocity constants."

Edward Kasner: "The group generated by turns and slides."

Edward Kasner: "Catenaries in an arbitrary field of force."

W. B. Carver: "Degenerate pencils of quadrics connected with $\Gamma^{n+2}_{n+4,n}$ configurations."

C. F. Craig: "On a class of hyperfuchsian functions."

Virgil Snyder: "Surfaces and congruences derived from the cubic variety having a double line in four-dimensional space."

W. B. Ford: "Irreducible homogeneous linear groups in an arbitrary infinite field."

Arthur Ranum: "On certain solids in riemannian space."

Arthur Ranum: "On the rank of a matrix."

H. B. Phillips: "Polygons on a quadric surface."

J. G. Hardy: "Note on a theorem of Pirondini concerning four-dimensional curves."

E. B. Coble: "Combinants of binary forms."

The twenty-fourth regular meeting of the Chicago Section was held at the University of Chicago on Friday and Saturday, January 1–2. The next meeting of the society falls on Saturday, February 27, at Columbia University. The San Francisco Section will meet on the same day at Stanford University. The sixteenth summer meeting and sixth colloquium will be held at Princeton University during the entire week September 13–18. The first two days will be devoted to the regular sessions for the presentation of papers. At the colloquium, which will open on Wednesday morning, the following special courses of lectures will be given: Professor G. A. Bliss, "Existence theorems in analysis"; Professor J. H. Jeans, "Statistical mechanics"; Professor Edward Kasner, "Geometric aspects of dynamics."

F. N. Cole,
Secretary

SOCIETIES AND ACADEMIES

THE INDIANA ACADEMY OF SCIENCE

The annual meeting of the Indiana Academy of Science pursuant to the new plan of holding meetings at the various institutions of learning in the state, was held at Purdue University on November 26–28. A large representation of the educators of the state was present and many papers were read that were of interest and importance. Thirty-five names were added to the roll of the membership, and a number of men who once were residents of the state and active members of the academy were elected to non-resident membership. The retiring president, Professor Glenn Culbertson, of Hanover College, delivered an address on the subject "Deforestation and its Effects among the Hills of Southern Indiana." Significant among the papers read was the number bearing on practical scientific problems. Following is the program in full.

General

"Work of the Pathological Laboratory of the Central Indiana Hospital for the Insane," Dr. Geo. F. Edenharter.

"New Species of Birds in Indiana," Amos Butler.

"The Recent International Congress on Tuberculosis," Severance Burrage.

"Biography and the Influence of Environment," Robert Hessler.

"Felkner Island, Waber Lake, Kosciusko County, Indiana," J. P. Dolan.

"A Strange Nurse," A. J. Bigney.

Drawing of the Indians at "Shaker" (made by an Indian in the Indian School), presented by Albert B. Reagan.

"Invasion of a School Building by Bed-bugs, *Acanthia hirundinis*, parasites on Chimney Swifts," H. E. Enders.

"Photographs of Morehouse's Comet, 1908I" (lantern), W. A. Cogshall.

"Selective Fertilization among Fishes," W. J. Moenkhaus.

"Nature Study," J. G. Coulter.

Botany

"Field Observations on Rusts for the General Botanist," J. C. Arthur.

"The Rust of Timothy," F. D. Kern.

"Notes on the Heterecious Rusts of Indiana," Aaron G. Johnson.

"Some Anomalies in the Endosperm of *Pinus*," D. M. Mottier.

"Notes on the Seedless Persimmon," Wm. L. Woodburn.

"A Preliminary List of the Fungi o Indiana," J. M. Van Hook.

"Testing Seed Corn by Specific Gravity," H. A. Dunn.

"Notes on the Flora of Cass County, Indiana," Robert Hessler.

"Bean Anthracnose," M. F. Barrus.

"Endophytic Algæ," Jacob Schramm.

"Report of Work in Corn Pollination," M. L. Fisher.

"Effect of the Recent Drought upon Forest Trees," Stanley Coulter.

"Difference between *Pinus tæda* and *Pinus palustris*," Katherine G. Bitting.

"A Forest Problem," W. H. Freeman.

"Botany in the High School," E. C. Snarr.

"The Killing of Mustard and other Noxious Weeds in the Grain Fields of Dakota," E. W. Olive.

"The Plankton of an Underground Stream," Will Scott.

"Anthracnose on Cereals and Grasses," A. D. Selby and T. F. Manns.

Chemistry, Physics and Mathematics

"The Meyer Molecular Weight Calculation," Percy N. Evans.

"The Vapor Pressure Method of Determining Molecular Weights," J. B. Garner.

"Reaction of Sulphuric Acid Interpreted upon the Basis of the Electrolytic Dissociation Theory," W. A. Ruth.

"Action of Alpha Bromacylesters on Sodium Acetylacetone," G. A. Reddick.

"Action of Alpha Bromacylesters on Sodium Benzoylacetone," J. B. Garner and G. J. Fink.

"Relation of Fats to Moisture Content of Butter," O. F. Hunziker.

"Note on a Class of Definitions," F. R. Higgins.

"A Graphical Representation of the Epsilon-Delta Definition of the Limit of a Function and Continuity," F. R. Higgins.

"The Beckmann Rearrangement," J. B. Garner.

"A Contribution to the Chemistry of Mucoid," C. E. May.

"Determination of Lead by Titration of Lead Chromate," C. E. Brooks.

"An Evolution Method for the Determination of Sulphur in Sulphates and Sulphides," F. C. Mathers.

"The Deterioration of Platinum through Ignition of Phosphates," R. E. Lyons.

"The Use of the Polariscope in Testing High Tension Insulators," C. F. Harding.

Geology

"Probable Origin of Depressions in the Mesa South of the Tijeras Canyon, New Mexico," Albert B. Reagan.

"Headwaters of the Tippecanoe River," J. T. Scovell.

"Origin of Cyclones and Anticyclones of Temperate Latitudes," W. A. McBeth.

"Some Drainage Modifications in Southern Indiana," W. M. Tucker.

"Soil Survey of Davies County," L. C. Snyder.

"Caves and Cave Formation of the Mitchel Limestone of Indiana," F. C. Greene.

Zoology

"The Nasal Muscles of the Reptiles," H. L. Bruner.

"Swell Mechanisms of Vertebrates," H. L. Bruner.

"Life Zones of Indiana as Illustrated by the Distribution of Orthoptera and Coleoptera within the State," W. S. Blatchley.

"Animals of the Olympic Peninsula, Washington," Albert B. Reagan.

"The Effect of Successive Removal on the Rate of Regeneration," Charles Zeleny.

"Proportional Regeneration," M. M. Ellis.

"Curves Representing the Rate of Regeneration," M. L. Durbin.

"Evidences for the Circulation of a Mixed Blood in the Adult Reptile and Amphibian as well as in the Fetal Mammal and Bird," A. G. Pohlman.

The following were elected officers for the ensuing year:

President—A. L. Foley, State University.

Vice-president—P. N. Evans, Purdue.

Secretary—J. H. Ransom, Purdue.

Assistant Secretary—A. J. Bigney, Moore's Hill College.

Press Secretary—G. A. Abbott, Indianapolis Manual Training School.

Treasurer—W. A. McBeth, State Normal.

Editor—H. L. Bruner, Butler College.

J. H. RANSOM,
Secretary

THE PHILOSOPHICAL SOCIETY OF WASHINGTON

THE 656th meeting was held on December 5, 1908, Vice-president Wead in the chair. The evening was devoted to hearing the president's annual address, delivered by Dr. L. A. Bauer, who spoke of "The Instruments and Methods of Research."

The full text of this address will soon be published in volume XV. of the Bulletins of the Philosophical Society of Washington.

THE 38th annual meeting was held December 19, 1908, President Bauer in the chair.

The following officers were duly elected for the ensuing year:

President—Simon Newcomb.

Treasurer—Bernard R. Green.

Secretaries—G. K. Burgess and R. L. Faris.

General Committee—W. A. DeCaindry, R. A. Harris, E. Buckingham, E. G. Fischer, L. A. Fischer, L. J. Briggs, P. G. Nutting, W. S. Eichelberger, F. A. Wolff.

R. L. FARIS,
Secretary

THE BIOLOGICAL SOCIETY OF WASHINGTON

THE 449th meeting was held November 28, 1908, with President Stejneger in the chair. Mr. H. W. Clark noted the occurrence of maple seeds gathered into clumps and partly buried n the ground under the trees, without apparent reason. Dr. L. O. Howard cited a new problem in the distribution of the gypsy moth. Distribution has been supposed to be only by caterpillars dropped upon and carried by moving objects, as carriages and the like. Isolated colonies of the moth have now been found in the woods far from roads or paths. The moths can not fly and it is yet unknown how the dissemination was accomplished. Information or suggestions were requested, the point being of much practical importance. The part which birds or heavy winds may play is problematical.

The regular program consisted of an address by Dr. F. Creighton Wellman on the "General Biological Conditions in Angola, Portuguese West Africa." The speaker occupied an hour with an interesting account of general conditions, citing freely from his notes, which were especially rich on the botanical side, on species of both flora and fauna in many groups.

THE 450th meeting was held December 12, 1908, in George Washington University Hall, with President Stejneger in the chair. The program consisted of an illustrated lecture by Mr. Ernest T. Seton, entitled "Two Thousand Miles by Canoe to the Arctic Region."

The 451st meeting, being the 29th annual meeting for the election of officers, was held December 26, 1908, with President Stejneger in the chair. The following were elected for the ensuing year:

President—T. S. Palmer.

Vice-presidents—E. L. Greene, E. W. Nelson, W. P. Hay, J. N. Rose.

Recording Secretary—M. C. Marsh.

Corresponding Secretary—W. H. Osgood.

Treasurer—J. W. Gidley.

Councilors—A. D. Hopkins, A. K. Fisher, A. B. Baker, David White, Vernon Bailey.

M. C. MARSH,
Recording Secretary

SECTION OF GEOLOGY AND MINERALOGY OF THE NEW YORK ACADEMY OF SCIENCES

AT the regular monthly meeting of the section on November 2, the evening was given to the presentation and discussion of a paper entitled "A Contribution to the History of Mt. Pelé, Martinique," by Dr. Edmund Otis Hovey.

The author described, with the aid of many lantern slides, the conditions on and near Mt. Pelé during his visits in May–July, 1902, February–April, 1903, and April–May, 1908, and illustrated particularly the devastation wrought by the early eruptions, the disposition and distribution of material thrown out by the volcano, the building up of the spine of 1902–3 and its subsequent destruction, the advance of erosion since the cessation of eruptions and the restoration of vegetation in St. Pierre and upon the flanks of the mountain. The paper also described the area of fumaroles in the valley of the Riviere Claire and gave the arguments for the probability of these being true fumaroles. Temperature observations were made also in the great fissures of the new cone, where, by means of an electric pyrometer, temperatures as high as 515° C. (959° F.) were obtained.

The paper will be published in full in the *Bulletin of the American Geographical Society.*

CHARLES P. BERKEY,
Secretary of Section

THE AMERICAN CHEMICAL SOCIETY NEW YORK SECTION

THE third regular meeting of the session of 1908–9 was held at the Chemists' Club on December 11.

Messrs. H. S. Miner and M. C. Whitaker presented a paper on "The Rare Earths—their Production and Application." Mr. Miner spoke of the sources of the so-called rare earths, described the forms in which they occurred and the methods of mining and purifying them. He then gave a résumé of the development of incandescent gas lighting, describing the researches of the early workers on the subject and indicating many problems yet to be solved. Mr. Miner illustrated his subject by a splendid collection of raw and purified materials used in making Welsbach mantles. Mr. Whitaker described the manufacturing processes and different forms of mantles used in this country and abroad. He showed numerous lantern slides to illustrate the structure of the mantles and the machinery used in making them.

The other titles for the evening were as follows: "A Volumetric Method for the Determination of Barium," A. E. Hill and W. A. H. Zink; "The Ultra-microscope and some of its Revelations," Jerome Alexander; "The Potential of Iron Calculated from Equilibria Measurements," A. B. Lamb.

C. M. JOYCE,
Secretary